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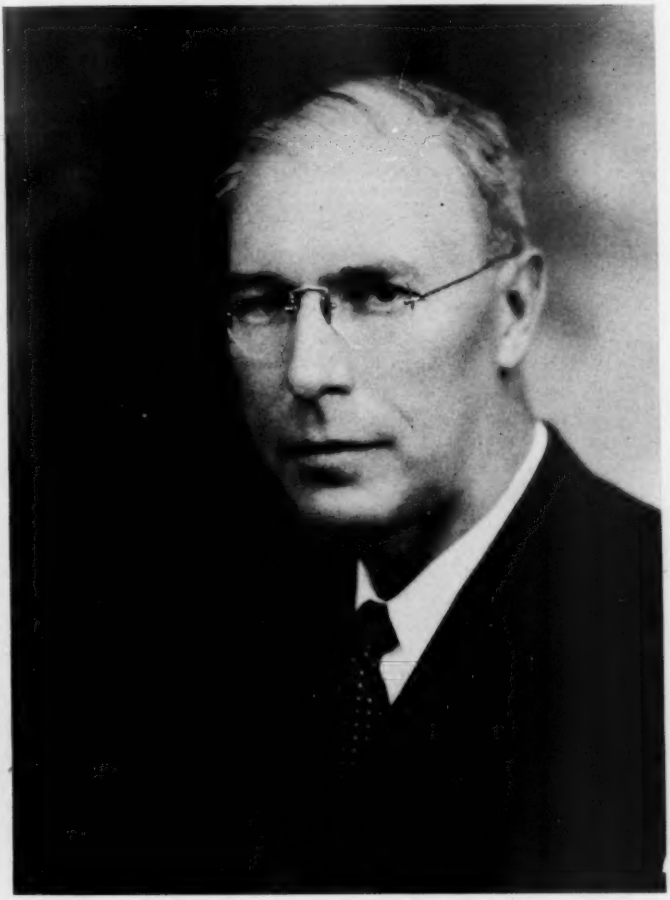

LEO R. TEHON, President, 1946-1947

MORNING ADDRESS

ARCHEOLOGY AND SOCIAL CHANGE

J. C. McGREGOR
Illinois State Museum, Springfield
First Vice-President, Illinois State Academy of Science

Just a year ago the retiring president, Dr. Emerson, read before this academy a thought provoking paper on the biological basis of social cooperation, wherein he stressed the crucial social problems then confronting humanity, suggesting certain biological and ecological principles which it was felt may bear on the interrelations of human society. The same appalling problems still confront us, with little change. Such being the case it may be profitable to continue this general discussion, somewhat in the nature of a running symposium, by bringing to the attention of this group the contributions of another field, that of archeology.

Man has undoubtedly been a subject of consuming interest to man since the beginning of human history, and there is little doubt that the human species has been subjected to a more searching examination than any other animal species. Every individual must necessarily spend a lifetime in the study of other people; yet with all this research and accumulated knowledge, society is repeatedly confronted with crises of various sorts, of which the present is beyond any question the most filled with promise of dire consequence. Many of us have heard the implied, or specific charge, that social science has failed miserably to keep stride with the development of the physical sciences.

Even if it be admitted that such a charge is true, and it probably is, it is somewhat unjust at a time when the physical sciences have enjoyed a war time stimulation far beyond their normal status, even in the present age. However, if a social atomic bomb is to be exploded in time to neutralize the effects of the physical atomic bomb, social thought must be revised as radically and put into effect as forcefully as thinking and action in the physical sciences. But society is resistant to social change, and if the necessary immediate readjustment is to be effected every effort must be made now to determine how such evolutionary processes function.

This paper does not attempt to answer all the social problems which are so urgently crying for solution; it rather points up the possible contributions of one small field to a better understanding of the mechanics of change. To do so, not only must the biological sciences be called upon for assistance, but all the physical and social sciences must be mobilized as well.

ARCHEOLOGICAL AIMS AND METHODS

It has long been my conviction that the fundamentals of a complex society are generally obscured by the proliferation of incidentals, for it is so easy for an abundance of fascinating trees to obscure the broad outlines of the forest. Also, if we are ever to understand the operation of complex society, and all society is more or less complex, we must first study the more simple society and resolve it to understandable fundamentals. This principle has been subscribed to by a long and illustrious list of anthropologists, and is today reflected in the work of Redfield on the mechanics of social change the Maya are now undergoing, and by Kluckhohn in his long range Navaho studies at Ramah, New Mexico.

However, such studies are limited to a comparatively short span of observable time, and if we are to have the desirable depth of perspective of the evolution of simple society, so as to understand the mechanics of broad social change, we must of necessity employ history. Unfortunately it is a well known fact that simple society almost universally has no written history, and it is therefore necessary to turn to archeology to supply the missing pages in the record of the story of man.

Kluckhohn has expressed a critical attitude toward archeology when in 1940 he said:[1] "Do researches which require large funds for their support require no social justification other than that of quenching certain thirsts for knowledge on the part of a relatively small number of citizens? If archeologists and ethnologists have hardly begun to ask themselves the tough-minded query —so what?, evidence is not lacking that this question has occurred to research foundations and other sources of financial support. Personally, I suspect that unless archeologists treat their work quite firmly as part of a general attempt to understand social behavior they will, before many generations, find themselves classed with Aldous Huxley's figure who devoted his life to writing a history of the three-pronged fork."

Just what is the case of archeology, and where does it stand among the sciences of the study of man today?

If we are willing at the outset to admit that the immediate aim of archeology is the re-creation of history from prehistoric data, and are willing to let universal laws become evident as a result of the study of these historical sequences, we may now proceed to a more careful examination of how history may be wrung from prehistory. The activities of man are apparent in two broad categories. 1. The material remains which result from his efforts at production or creation. These are known as material traits, and in our own society are rather fully represented by salable articles. 2. The mental attitudes, or nonmaterial traits, which consist of such elusive qualities as the folkways, mores, laws, rules and regulations which control human relations.

It is obvious that the source data of true archeology, lacking all writ-

[1] Kluckhohn, Clyde, "The Conceptual Structure in Middle American Studies," From, "The Maya and their Neighbors," D. Appleton-Century Company, Inc., 35 W. 32nd St., N. Y. 1, New York, 1940. Page 43. (Permission to quote given in letter of May 12, 1947.)

ten history, is confined wholly to material traits, and because they are perishable many data are limited to the more resistant of even these traits. The preservation of any material through centuries depends on many factors, and at best only a small portion of any group survives. Thus, at the outset, the archeologist is limited to laboring with only a part of the tools available to other branches of social study. However, as will be demonstrated later, it is sometimes possible, through analogy with living groups, to suggest certain non-material traits.

One of the most vexing problems confronting every archeologist is the ordering of his data into relative and absolute temporal sequences. By comparison the equally necessary technique of arranging traits into typological sequences is a very simple matter. The most common and most satisfactory method of establishing relative chronology is by a study of stratigraphy, although other disciplines, such as geology and paleontology, chemistry in soil analysis, and even artifact sequences may also be of aid. In the Southwest, tree-ring dating revolutionized archeological research, and is in fact of such importance that I would like to take a few minutes to discuss it in some detail.

Dr. A. E. Douglass, a southwestern astronomer, in 1905 began study of tree growth, as reflected in their ring sizes, in an effort to correlate sun spot cycles with growth. With comparatively little effort, once suitable material was made available, he was able to demonstrate that rings grown in certain years were more or less consistently small, or large. However, he was unable to extend this record back for more than four or five hundred years.

Additional material, this time from prehistoric and ruined southwestern dwellings, was next secured. An examination of numbers of these specimens indicated that they also carried consistent ring growth patterns, which could be cross-dated to form floating chronologies. The ensuing search for specimens which would bridge the gaps and so produce one long chronology is a saga of exceptionally fascinating interest.

Suffice it for our present purpose only to report that a continuous tree-ring sequence is now available for the Southwest from A. D. 11 to the present. This span covers all major periods of well represented culture stages of the prehistoric inhabitants of this area, and has made it possible to speak of events in past time in terms of years in our own calendar. The most immediate and obvious result of this dating was that almost every previous estimate of archeological dates had to be revised downwards, or shortened, in some cases radically. Here then, is evidence that culture changes more rapidly than might be expected.

Many of you will be interested to learn that the Tree Ring Laboratory at the University of Chicago has, within the past few months, released dates on Kincaid, an archeological site in southern Illinois, which fall within the 16th century A.D.[2] Archeologists are already busily engaged in interpreting these dates in terms of other sites from which

[2] Paper read by Robert E. Bell at the December 1946 Meeting of the American Anthropological Association, and affiliated societies, Chicago, Illinois.

trade material came to Kincaid, and in estimating expanded dating. For example, it has been suggested that the Middle Mississippi occupation at Kincaid probably began about A. D. 1450 and lasted to about A. D. 1630. Through the identification of trade objects the famous Cahokia Mounds may be dated as of a somewhat similar span. Thus with additional tree ring research it may be safely predicted that other both earlier and later sites and cultures will soon be dated, and so may be assigned to an absolute chronology.

Before turning to a serious examination of one archeological area, two other important methods should be briefly characterized. Extensive surface survey, occasionally supplemented by small-scale excavation testing, has proved one of the most effective and productive of archeological techniques. It depends on type descriptions of various artifacts and artifact typologies, and on relative or absolute chronology. Systematic survey, and the thorough digestion of its products, will add one more most important and fundamental field of knowledge to the study; that of geographic distribution. This prepares the background for the presentation and ordering of the available data.

If any mass of raw data is to be evaluated and interpreted, it must be arranged according to some predetermined systematic pattern. Any attempt to arrange archeological material in preparation for interpretation involves what might be considered four dimensions. Traits, which are physical representations of past events, must be ordered first in some scheme which places them in a two-dimensional geographic plane, and in a third crossing temporal sequence. I have elsewhere suggested a simple physical method by which this ordering may be accomplished.[3] If several cabinets containing a series of drawers are employed, each cabinet representing a particular geographic area and each drawer a pre-determined time period, artifacts may be placed in their appropriate case and drawer. By simply pulling out all drawers of one level, and then successive levels, it is possible to demonstrate where and when a given artifact occurred, where it spread, and when it disappeared. But this is not in itself the creation of history from prehistory, for a fourth dimension must be added.

A simple definition of history has already been suggested; it now is imperative that history be further defined. One of the tenets of anthropology is that any social structure, like any physical structure, is more than a simple sum of its constituent parts. Certainly, therefore, history must be more than the simple ordering of determined traits, or events, in their proper temporal and spacial niches. It must be the interpretation of the interrelationship of these events in terms of social patterns and principles. It is the determination of the why and how, in so far as possible, of the interrelationship of events that adds zest to archeological, and in fact all anthropological studies, and will in the end result in an understanding of the dynamics of culture, or culture change, growth, and modification.

[3] McGregor, John C., "Southwestern Archaeology." John Wiley & Sons, Inc., New York, 1941, Page 55.

This is the fourth dimension just referred to.

These, briefly and somewhat schematically stated, are the aims and methods of archeology. Almost nothing has been said about techniques, for they have little bearing on the discussion to follow.

What has been, and is now being accomplished, by these means?

Prehistoric History of the Southwest

Of all the areas of the world where archeological research has been undertaken, probably our own American Southwest is the most significant. This statement is based on several facts not generally appreciated. Systematic and intensive archeological research has been energetically prosecuted there for more than six decades. The arid physical environment, combined with a physiography which has provided many natural caves and shelters attractive to man as habitations, has made possible the preservation of articles which otherwise would have deteriorated. The arid environment has also tied man closer to the soil than in many other areas in the world, and has called forth ingenuity in the adaptation of life to a variety of physical and ecological environments. Thus a number of somewhat diversified evolutionary lines are represented.

Of more importance is the fact that here is found a social evolution which spans all stages, without break, from an exceedingly simple semisedentary-seminomadic way of life, to the highly compact, wholly sedentary stage represented today by the living Pueblo groups. As descendents of their prehistoric ancestors in the same area, these latter people supply much of the information, which through analogy, makes possible interpretation and comprehension of events indicated by artifacts in prehistoric horizons. There is also the unique contribution of tree-ring dating, already mentioned which has made possible the specific dating of all major stages in the unfolding of Southwestern cultures.

It is these reasons, plus the fact that I am most familiar with the achievements of this area, that prompt me to turn to this field as a source of material to illustrate this discussion. As a logical beginning the following simple summary of Southwestern history is offered.[4]

The earliest known evidence of man in the Southwest consists of stone artifacts which through various geological and paleontological processes have been correlated with now extinct mammals, and dated as on the order of some fifteen thousand years old. The famous Folsom Culture is probably the best known of these early finds. Unfortunately this and other related finds of somewhat comparable age lack any human remains, and they consist of such an impoverished trait complex that little is known concerning them, beyond a few tools, and the fact that the people appear to have been purely nomadic hunters.

The first more completely represented culture is the Cochise, known from southeastern Arizona. Stone work was expanded by these people to include what is probably the earliest use of grinding stones by

[4] In a paper such as this, questions still somewhat controversial must be treated as though settled.

any group in America, perhaps in the world, for they have been dated by Antevs as of about ten thousand years old. These people lived in the pluvial, or immediately postglacial period, and their remains are commonly found as camps on the borders of long since dry lakes. Two human skeletons, probably assignable to this period, have been found, but have not as yet been studied and reported.

None of these early cultures is sufficiently rich to make possible much in the way of interpretation, but by the time of Christ other people living in the southern portion of Arizona and New Mexico were well established, and are more fully represented and known. These have been designated as the Mogollones, and at this early period they had pottery, had built more or less permanent homes, practiced an economy divided between hunting, gathering, and a simple agriculture, and were individuals of some consequence.

At about this same time another related group invaded the desert country of southern Arizona to establish a long dynasty of rich cultural development. These people are known as the Hohokam. They were sedentary individuals with permanent homes, pottery, a more or less specialized stone industry, and were faced with the necessity of adaptation to a decidedly inhospitable environment. Because of the exceeding aridity of this region they settled along the permanent streams and in the foothills of the isolated mountain ranges where water was assured.

Slightly later, probably in the third or fourth century A. D., the Basket Makers settled in the northern portion of Arizona and southern Utah. They were seminomadic, practiced only simple agriculture, and relied for subsistence on gathering and hunting. Because of their way of life they constructed no permanent homes in the early portion of their reign, and lacking pottery they turned their interests and energies to the production of containers and objects of soft materials, such as fibers, in which they excelled for their time.

With these three groups accounted for we have the basis of what has commonly been accepted as the three roots, or fundamental cultures, of the Southwest. From them, as the centuries gradually unrolled, and perhaps stimulated by occasional outside influence, all of the later cultures sprang. Perhaps these three roots should even be reduced to two by combining Mogollon and Hohokam as two stems under one root, the Cochise.

By A. D. 700, the three same groups were still represented in the Southwest, although a fourth, the Patayan, may have become further differentiated, or introduced into the area along the Colorado River. Little is known about it. Mogollon was thoroughly entrenched, and although it had achieved comparatively little evolutionary progress within itself, it was exerting considerable influence on other groups, especially to the north and northwest. As they moved northward they came into contact, sometimes violently, sometimes apparently peacefully, with the resident Basket Makers, and to them contributed the bow

and arrow, at least the rudiments of pottery making techniques, and the principles of house construction. At this time the Hohokam were busily engaged in building the extensive system of canals that was to characterize their existence and make possible an expansive agriculture in the most arid portion of the Southwest. They had also established contacts with Mexico, as is testified to by shared trade, and such mutual traits as ball courts.

Three hundred years later, or by A. D. 1000, the picture had changed more or less radically. The Hohokam people had about reached their peak. They have been mentioned first because Hohokam represents an even continuation of preceding developments.

In the north the result of the Basket Maker - Mogollon contact seems to have been the development of what is known as Pueblo Culture, most spectacularly in the four corners area, where large multiroomed pueblos had been evolved, the pattern of economy firmly established as one of a highly sedentary agricultural nature, and pottery had developed to an equally rigid pattern.

On the other hand the Mogollones had suffered reverses. Apparently having shot their bolt northward to the Basket Makers they began to wane as a distinct entity, and with the southward expansion of Pueblo influence more and more took on a Pueblo cast. The general economy was also shifting from a hunting to a more sedentary type.

During the fourteenth century many radical changes took place in the Southwest, probably the most striking of which is directly traceable to the great drought, a period of about twenty years at the end of the century, which tree rings have demonstrated was a time of very little rainfall. This occasioned a mass movement of Pueblo people southward and eastward, where they pressed on others, forcing them still farther south and east. At this time Pueblo Culture had reached a high level of development, and as it moved south and eastward it was modified by every local group with which it came in contact, but on the whole retained its major works of art and general culture with little change.

What remained of Mogollon was quite overshadowed by the march of Pueblo Culture. The descendants of the Mogollones were being forced into the southwestern corner of New Mexico, where they were to have one last florescence as Mimbres.

Far to the south the Hohokam were also feeling the pressure of Pueblo contact, and the most remarkable observation which may be made about them at this time is that they apparently existed peacefully, but quite independently, side by side with Pueblo culture and people. The Hohokam had definitely passed their peak, and were making no more contributions to Southwestern development, while they clung tenaciously to most of the features of their own way of life.

What became of these several groups is a matter of consuming interest to archeologists today. The remnants of the Mogollones moved first into southwestern New Mexico, and there is some evidence that they eventually migrated on into north-

ern Mexico, but what then became of them is unknown. Many of the Pueblo people remained in the north, and are represented today by their descendants in Arizona and New Mexico, but those who moved far south to mingle with the Hohokam simply seem to have disappeared. Perhaps they once more moved north when conditions there again became advantageous. Most fascinating problem is the final disposition of the Hohokam, for their ultimate fate is shrouded in the deepest mystery of all. Perhaps they moved west to the Colorado River, there to become members of the Yuman speaking groups, or remained in the Gila and Salt River valleys to be absorbed into the Pima and later arrivals into this area.

Three hundred years later, or by A. D. 1600, about the present pattern of occupation of the major Indian groups in the Southwest was at least roughly formed. The Pueblo Indians were firmly entrenched in approximately their present homes in northern Arizona and New Mexico, and there is much evidence to lead us to believe the nomadic Apache and Navaho bands had arrived, and were rapidly becoming established. Since from this time on written records supply the necessary data for historical reconstruction, this summary outline of history can be terminated at this point.

However, major outlines rest on the meticulous demonstration of innumerable bits of history. It is therefore proposed, in the remainder of this paper, to examine a few of these small historical fragments, to see how they have been arrived at, and of what they consist.

Physiographic Provinces

Some years ago it was my privilege to be briefly associated with J. W. Hoover, geographer of Tempe State College. At that time he was greatly interested in establishing Southwestern geographic provinces, and I was immediately struck by the fact that in most cases these provinces seemed to coincide with the areas of prehistoric culture as then understood. Continued research has more clearly confirmed this association.

The Southwest may be readily divided into major physical areas, with the northern and central portion composed of a high flat plateau, dissected into broad valleys by only a few streams, and with many box canyons. This is bordered on all sides, except the extreme north, by a continuous area of dissected mountain country, or on the east by mountain ranges. South and west of this band is the typical arid desert, again with only a few major streams in broad valleys, and to the east the high plains. The three roots, previously described, are assignable in broad measure to these separate regions. The Hohokam had their entire development, in fact complete existence, in the desert area. The Mogollones, except for early sporadic and late migratory movements while under pressure, were dwellers of the mountain region. The Basket Maker, and later the Pueblo development, was almost entirely confined to the plateau area, with the exception of the rather brief southward expansion already discussed.

These broad provinces are of course divisible into many regions, each with characteristic peculiari-

ties, and each with its own distinctive variant of the broader culture pattern. However, for the moment, it would be most profitable to limit our discussion to a consideration of the effect of environment on the broader groups. Probably the most clearly marked effect of environment on culture is found in the desert area and on the history of the Hohokam. With their invasion of this uninviting environment they at once committed themselves to a culture adaptation to an unusual situation. The main streams, the Gila and Salt rivers, predetermined the major pattern of their settlements, and as soon as population concentrations reached any dimensions, demanded the use of irrigation in the prosecution of agriculture. With thinly scattered populations floodwater irrigation sufficed, but as permanent populations increased irrigation was developed, until ditches supplied water to a total acreage approaching that under cultivation at the beginning of this century in the same area.

The development of such engineering projects thoroughly tied the people to the soil, rooting them in one location, so long as this method of agriculture was locally effective. As a result the development of Hohokam culture followed a long and regular path, with its inception at about the beginning of the Christian era, and reaching a peak sometime about the eleventh or twelfth centuries A. D. A gradual decline then set in, and by probably A.D. 1450 they had reached the point of extinction, or had been absorbed by other groups. This gradual development to a high level and then decline might be considered characteristic of a firmly entrenched and smugly satisfied group.

Opposed to this is the Mogollon, which was limited to the mountain section, and was, because of the opportunities offered on every side, more preoccupied with hunting as a means of subsistence than any of the later groups. This apparent restlessness and fluidity, early led these people northward to contact and influence the Basket Makers, and later made them easy prey to the solid advance of the Pueblo people and culture. With a lack of abundant natural resources to supply large concentrations of population, and their persistent adherence to an outmoded way of life, their eventual assimilation, or dispersion, was a foregone conclusion.

On the other hand the early conversion of the Basket Makers to a new mode of existence, prodded by the necessity stimulus of the encroachments of Mogollon, with the resultant population concentrations and the development of a permanent agriculture and elaborate social structure, assured their perpetuation. Here, as is always the case, the transition period, though obviously difficult, was one of great stimulation. A new sedentary way of life was substituted for an old seminomadic form, and as soon as the new pattern had been set, with for the first time security and abundance of leisure, advance was very rapid. Population increase, and social and technical stability, then led naturally to geographic expansion, with continual additional stimulus. It was, therefore, not until the arrival of overwhelming ag-

gressive foreign European elements that Pueblo culture was forced to retreat, consolidate, isolate, and in at least some characteristics stagnate.

Cross-Dating Sites

Much more, and in many cases in great detail, could be said on this line, and shortly one or two other examples of social processes will be considered more microscopically, but just now it becomes necessary to examine another technique. Continued reference has been made to dates, yet it is a matter of general knowledge that tree ring dates in the Southwest are largely confined to the Plateau area, and there to the more datable kinds of conifers. Also, the earliest date so far secured in association with human culture stages is an early Basket Maker beam, found in Dupont Cave in Nevada, and dated as A. D. 217. How then may dates be assigned to the Hohokam stages, particularly in their earlier portions at about the beginning of the Christian era?

The most intensive work of dating, and correlation of dates with culture stages, has been that done by the Museum of Northern Arizona in the general vicinity of Flagstaff. Here it is demonstrated that the average rate of human cultural evolution resulted in distinguishable differences about every two hundred years. Once datings had been established for local groups it was then possible, by an involved process which I have referred to as "seriation," and through the establishment of cross finds, to date sites and cultures where no tree ring dates were available. For this cross-dating it was early recognized that pottery was of the utmost aid, in that once made it was practically indestructible, was on the whole abundant, was subject to continual fad changes, and might be easily collected, stored, and studied. It is by these means—cross-dating through trade pottery, and projection of dates according to what appears to be an established pattern rate of development—that dates have been assigned with some evidential basis to early periods, and also to sites without the tree ring area.

Culture Evolution Cycles

However, one of the most obvious results of this study of Southwestern archeology is that the development and change of human culture is not unilateral, and over long periods is not uniformly continuous. Rather, the history of one culture is that it tends comparatively to fluctuate with various periods of rise and regression, though in every case to gradually rise to a peak, and then more or less gradually decline. The problem now is to attempt to determine, in a few selected cases, why such a pattern forms.

Perhaps one of the most common causes of decline is the failure of individuals, and society, to readjust to changing environmental conditions. Halseth, and others, working on the problem of Hohokam decline have suggested it is associated with the difficulties which developed in their irrigation projects. He has suggested specifically that continued spreading of water over the land waterlogged it. The evaporation of quantities of water from the soil, in the arid atmosphere, led to the deposition of a layer of lime, known locally as caliche, anywhere from a foot to two or three feet below the

surface. When this had formed a seal beneath the soil, water could no longer penetrate beyond this seal but rapidly evaporated, thus rendering the lands useless to further agriculture. This is a problem still confronting irrigation farmers in this same area. Such an explanation in conjunction with theories of invasion, which are based on convincing evidence, and perhaps several cycles of continued stream erosion as a result of serious droughts, which made necessary the repeated removal upstream of canal inlets, may be the answer of the tip of balance from progression to regression.

Culture Contacts

One of the most important factors contributing to the evolution of culture is contacts. This may be demonstrated in any one of a number of cases in Southwestern prehistory, is demonstrable in history throughout the world, and is in operation on a grand scale today. The effect of Basket Maker and Mogollon contact has already been pointed out and discussed. Another example, also taken from the work of the Museum of Northern Arizona, demonstrates how a natural phenomenon may cause a social upheaval.

Some years ago it was learned that sometime in the eleventh century A. D., a volcano, something like Paricutin in Mexico, erupted and covered the surface of the ground for many square miles with a layer of volcanic ash. This ash, like that at Pompeii, covered old dwellings, but soon after it had been distributed through wind action to a more even and thinner cover people began to move back into the area. Shortly the movement became almost a land rush, in which elements of all the major roots were represented; Hohokam from the south and west, Mogollon from the south and east, and Pueblo from the North. Unfortunately it was directly in the center of this horrible mixture that this museum first began serious work, and it can be imagined what a scramble of confusing problems had to be resolved before any semblance of order could be established in our data. However, it was from this amazing congenial mixture of population that almost immediately a culture of unusually rich character sprang.

An incidental practical result, of immediate application to modern practices, came from one phase of this study. In an effort to determine why the cinder covered area was so attractive to humans a study of tree growth in the cinder field was undertaken, and compared to that outside it. It was learned that the fine dark cinders formed a mulch above the clay soil, acting to conserve moisture and at the same time absorb heat; that tree species sharply dipped down into the cinder areas, in some cases a thousand feet from their normal environments; and that a cinder depth of some eight or ten inches was the optimum condition for growth. This information was passed on to the local agricultural adviser, and you can hardly imagine my surprise the next summer when I came upon luxuriant corn fields growing at seven thousand feet from extensive cinder flats, where the farmer had only to plant and reap his harvest, since cultivation was not only impractical but unnecessary.

Culture Isolation

In general the evidence from the Southwest is that at no time, and among no people, was there any extended or extensive isolation. Several excellent recent studies of prehistoric trade have shown that contacts were far flung. Many contacts were continuous over long periods. Not only was trade extensive, but physical contact, often resulting in physical and social mixtures were common. There is evidence of mutual influence between Mexico and the Hohokam. Early contacts, even the exchange of such artifacts as pots, between the Hohokam and Mogollon has been demonstrated by detailed mineralogical studies. The Mogollon and Basket Maker contact has been repeatedly stressed, as has the later Pueblo contact with Mogollon. It should also be noted that extensive studies have been made and several papers written on the important influence exerted on the Pueblo development by Hohokam, and on the later Pueblo contact with and influence on Hohokam. The important lesson to be learned here is that cultural enrichment has always resulted to one or both of the participating groups.

Another exceedingly important point affecting the development and change of culture is the need of available leisure time. When a group is continually confronted with the necessity of procuring a bare existence, cultural advance requires great individual effort. It was not until the Basket Makers became converted to a sedentary agricultural existence that they made any radically marked development, then it suddenly blossomed. Mogollon was probably limited, certainly retarded, because of persistently clinging to a hunting economy.

Economic, social, and war pressure from without a group is undoubtedly another factor strongly influencing social development. It has the effect of consolidation from within to combat the pressure from without. However, it may induce stagnation, as apparently happened when pressure of nomadic tribes historically induced the Pueblos to consolidate into a few defensible large villages. Or, under other circumstances, it may be responsible for a marked broadening of horizons, such as was the case of the Basket Makers, but this seems to be dependent upon tribal intermixture.

Just what influence on cultural change vigorous individual leadership may have is still a matter of debate. Archeology can contribute little or nothing to the question of whether the man is the result of the times or can develop the times. History and ethnology combine in two illustrations to shed some slight light on this question. Archeological research at Sikyatki, an ancient and ruined Hopi Pueblo, was followed with much interest by the first mesa Indians. One of these was a pottery maker, Nampeyo, and she was so struck with the designs of the ancient pots that she, almost alone, by copying them, inaugurated a revolution in the pottery of these people. A similar result was observed when Indians visiting the Museum of Northern Arizona were fascinated by still older pottery designs, and again introduced a revival of style among their people. But this question is dependent upon an-

other, that of the acceptance or rejection of proffered traits.

Trait Acceptance

There is much archeological and ethnological evidence that any superior trait will be readily accepted if in so doing it does not thereby disrupt other associated and integrated traits and traditions. The steel axe was readily accepted as a substitute for the stone axe, the steel knife and the copper or iron pot for the stone knife and pottery vessel, but the Christian religion was either flatly rejected or only superficially accepted. Religion has its roots deep in the total culture of the people, with ramifications in every phase of activity. Archeology, like history, gives every evidence of the reluctance of religions to change. As example the writer found an individual buried in a small pueblo just west of Flagstaff, accompanied by sufficient obviously ceremonial paraphernalia that the ceremony represented could be identified by modern Hopi Indians. He was interred sometime early in the twelfth century, so here is evidence of a religious ceremony which persisted for more than eight hundred years with little or no change. We may therefore speak with some conviction of stable and unstable institutions and practices.

Revolutions, Crises, Barriers, Frontiers

Not long ago Gordon Childe wrote a book entitled "What Happened in History,"[5] and in it suggested that the main stream of cultural history followed a pattern which might be characterized in four stages. Of more interest at the moment is his concept that these developmental stages are separated by revolutions; the first and second by what he calls the Neolithic or food-producing revolution, the second and third by the urban revolution, and the third and fourth by the industrial revolution.

This concept of revolution is closely allied, though on a grander scale, to what Colton has called a crisis,[6] To understand what he means by a crisis it is necessary to explain what he has in mind when he refers to frontiers and barriers. When foci, which are minute temporal, areal, and cultural divisions of roots, are plotted on maps for given periods, frontiers become evident. In north central Arizona in the vicinity of Flagstaff he has worked out in great detail at least seven such frontiers. All have different qualities, some being relatively stable over a period of years, while others are fluid, with one group advancing at the expense of another.

After having examined the character of all these frontiers Colton concludes that any geographical condition which makes an area unfavorable for human occupation may become a frontier, although it may be that no natural barriers are present. One such non-barrier frontier remained almost static for nearly 600 years. He visualizes a frontier as a semi-membrane, against which traits, ideas, and even people are beating like molecules in a liquid. People diffuse slowly through frontiers on trading or other excursions, whereas, as has been sug-

[5] Childe, Gordon, "What Happened in History." Penguin Books, Inc., New York, 1946.

[6] Colton, Harold S., "The Sinagua. A Summary of the Archaeology of the Region of Flagstaff, Arizona." Bull. 22, Museum of Northern Arizona. Flagstaff, Arizona, 1946. pp. 300-301.

gested, certain traits easily diffuse through these zones.

A crisis is then described as the breaking of this membrane, when both people and ideas freely flow across the frontier. Archeologically this is the most obvious type of crisis, but there surely must be many other less obvious types. Population shifts are probably only the outward evidence of the internal cause, or the true crisis. A suggestion of what a few of these causes may have been might be undertaken at this point.

If all of the tree-ring dates from the Southwest are plotted, it becomes evident that certain periods saw more construction of new dwellings, or repair of old ones, than others. Based upon what must be admitted as far from an ideal quantity of tree ring evidence it would appear that about A.D. 700, slightly past 900, about 1100 or 1130, and near 1300 are the most apparent disruptive periods. When this information is tested against the results of archeological survey, a much more complete pattern of population shifting becomes evident.

Unfortunately there is too little information available to enlarge upon his problem before about A. D. 1100, which incidentally appears to have been one of the most crucial dates of American history, but from that time on to the present it is fairly full. Considering only the area most intensively studied, that in the north central portion of Arizona, it may be seen that at about 1130 the Tsegi and Chaco canyons were abandoned, while the Wupatki, Kayenta, Hopi country, Winona and adjacent areas, were occupied. At about A. D. 1250 the Tsegi Canyon and Mesa Verde areas were reoccupied, while Wupatki, Citadel, and parts of the Hopi Country were abandoned. At about A. D. 1300 the entire San Juan, Little Colorado, and San Francisco peaks areas were abandoned, and the Hopi Country, the upper Little Colorado and the Verde Valley were intensively occupied. By A. D. 1400, or thereabouts, all of the Pueblo people had been gathered into the Hopi and Zuni villages from the Verde Valley, the Winslow area, and from the Hopi Butte country north to the Jeddito Valley.

Crises Causes

Just what the motivating causes of all these movements were it is impossible to determine at present, but some suggestions may be made. Some time ago A. E. Douglass personally outlined to me what he called the human cycle of site occupation. It was not new with him, but I have never been able to trace it to its proper source. This theory consists of the knowledge that new occupants in a virgin area will invariably choose a spot of precarious natural balance. This is usually at the edge of a forest, to supply construction and fuel, and an open or grassland area, to make possible agriculture. Occupation of the site, with the attendant stripping off of the cover, disturbs this balance, with the result that erosion sets in, the water table lowers, occupation becomes impossible, and the people move. When nature has once more re-created a balance the same region may, and often is, once more occupied.

There is much actual evidence, in cutting and filling of wash beds in canyons, that this is exactly what happened in the very areas which have just been characterized. Certainly such a cycle is demonstrated in the Tsegi Canyon system, the Chaco Canyon, and in parts of the Little Colorado Valley. However, humans are loath to make any change, and will usually resist it to the last possible moment. What is the actual trigger event that casts the last die is more difficult of determination. It may be a drought, or continued droughts, such as is known to have taken place in the late fourteenth century. It may be a cinder fall, such as that described for the Flagstaff area, which inaugurated widespread movements of people. Or it may be even so simple a matter as the interpretation of a dream on the part of one individual in a position of great influence.

So many more ideas of such fascinating possibility have sprung from the recent study of Southwestern archeology that I should like to be able to continue with a discussion of them, but this is impossible now. By way of conclusion it might be profitable to briefly review the several points covered, and to summarize them. For convenience they are listed in order as discussed.

Summary

1. Social development, when sufficient data are available, is found to have made strides more rapid than is generally otherwise believed to have been true, at least once a certain minimum level is attained.

2. Culture units tend to be confined to certain physiographic or environmental areas.

3. In turn physiographic and ecological environments by their nature tend to restrict or to encourage the advance of culture.

4. The evolution of culture is not lineal but fluctuating, although on the whole gradually rising to a peak, after which, in all specific cases, decline sets in.

5. Cultural decline is commonly traceable to the failure of individuals and society to readjust to changing environmental conditions.

6. Cultural evolution is greatly stimulated by contacts; the closer the contact, on the whole, the more rapid the advance, and cultural enrichment often results to both participating groups.

7. Pressure from without a group may advance cultural evolution within the group, by consolidation and pointing up purpose, but conversely it may so force a group in upon itself as to retard it.

8. Leisure time is a necessary adjunct of cultural development.

9. Cultural isolation has not existed to any extent in the past, and exists almost not at all today.

10. Vigorous individual leadership in pioneering advances may in some rare cases have influenced social development.

11. New ideas and objects, even concepts, offered a group will be readily accepted only if they are superior, or promise reward, and if they may be accepted without upsetting social integration.

12. Frontiers may or may not be determined by physical barriers.

13. Some frontiers remain stable for long periods, while others are constantly shifting.

14. Traits, ideas, and even people may slowly diffuse across frontiers, usually to the mutual benefit and stimulus of the parties involved.

15. When a natural or artificial barrier breaks down, a crisis develops at that frontier.

16. Crises may be the result of causes other than the breaking down of barriers and shifting of frontiers, for the "human occupation cycle" may also give rise to a local crisis, as may drought, or any other natural or social disruptive agency.

All of this is very well, and I believe it has given some sort of answer to the question of "so what?" raised by Kluckhohn, and quoted early in this paper, but we as individuals are concerned with the problems of the present, as well as a long time prospect of the future. Considering what is likely to result from the recent war in the immediate future there is some cause for optimism. Not only will physical science and technology advance, and be applied to problems of the convenience and productiveness of our daily lives, but the mass displacement of people throughout the world is sure to have a stimulating and advantageous effect on the development of culture. Displaced persons of superior quality will be drawn to the United States, because of our high standard of living and abundant opportunities. This will result in a great stimulus, which should mean, if the lessons of history and archeology are any indication, that we will soon lead the world in culture, as well as physical production, and in all other fields.

ARCHAEOLOGY AND ANTHROPOLOGY

CLAUDE U. STONE, *Chairman*
Peoria

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1. An Upper Mississippi House-pit from the Fisher Site: GEORGE R. HORNER, Wheaton College, Wheaton.

* 2. Hopewellian Dress and Personal Ornaments in Illinois: THORNE DEUEL, Illinois State Museum, Springfield.

* 3. A Consideration of Traits and Traditions in Archaeology: JOHN C. MCGREGOR, Illinois State Museum, Springfield.

* 4. Culture Relations at the Spiro Site, LeFlore County, Oklahoma: KENNETH G. ORR, University of Chicago, Chicago.

* 5. Paper: BYRON W. KNOBLOCK, Quincy.

6. A Seven-pound Copper Axe among 1946 Hopewell Discoveries: E. SCHOENBECK, Peoria.

7. The Succession of Woodland Horizons in the Carbondale Area: MOREAU S. MAXWELL, Logan Museum, Beloit College, Beloit, Wisconsin.

*Not published.

AN UPPER-MISSISSIPPI HOUSE-PIT FROM THE FISHER VILLAGE SITE: FURTHER EVIDENCE

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The Fisher site is located on the east bank of the Des Plaines River, which is one mile above the Kankakee River into which the Des Plaines flows, both forming the Illinois River. The Fisher site was formerly a large Indian village.

Formal archaeological work was begun by George Langford in 1906, 1927; and later work was done from 1931 to 1941 by the Illinois State Museum and the University of Chicago. Wheaton college excavated a house-pit (No. 48), located in the northwest portion of the village during June-July 1946.

Wheaton's purpose for excavating this house-pit was two-fold: (1) To contribute to the general knowledge of the site, and (2) To make further study into the sequence problem relating to Langford grit-tempered ware and Fisher shell-tempered ware.

Method

Our excavating technique was to stake the house-site area, in five-foot squares, using transit, level, and stadia rod. The base-line ran approximately north to west with the center-line extending north to east at a right angle from the center line. Digging began five feet behind the base-line (square —5R1), and the resultant trench, four feet deep, proceeded southeast on a ten-foot face, until the 25R1-25-0 squares were reached. The glaciated limestone, over which the village was built, made excavating exceedingly difficult. A similar procedure was repeated starting on the north-east line, at square 20L3-25L3. This trench continued to the southwest, on a ten-foot face, until the 20L1-25L1 squares were reached.

A field notebook record was kept of each day's proceedings, recording the bench-mark, recovered objects, and other data pertinent to excavation procedure and interpretation. Photographic records in black and white, color, and colored motion pictures were made as the excavation progressed. Recovered objects were kept in paper bags, each bag marked to represent a square. Triangulation was measured on all recovered objects. The entire house-pit was not excavated.

For those unfamiliar with the term "house-pit," we define it as a shallow foundation, 12 to 18 inches deep, made by clearing the top-soil, providing a clean level place for the floor of the dwelling. The soil from the floor was piled around the edges of the foundation, giving it an appearance of greater depth.

House-pit No. 48 was rectangular in shape and approximately 30 feet long and 25 feet wide with the long axis extending north to south. The pit revealed two house walls, one inside the other, similar in construction to house-pit No. 15, excavated by the University of Chicago and described by J. W. Griffin

(1944). The function of the double walls has not been determined. Inside the walls, on the floor of the house, were twin post-holes set at opposite angles suggesting uprights to support the roof. Other posts were recovered by the party. All were completely charred and partly disintegrated. It was not possible to take any of them out intact. The average post was five inches wide and 18 inches long. The broader butt ends showed incisions, probably made by a stone axe. Quantities of charred wood were found scattered over all of the floor. Such a large quantity may indicate that the structure was destroyed by fire. This wood has been identified as sulfur-budded or bitter-nut hickory (*Carya cordiformis*) by John Leedy of the botany department of Wheaton college. There is a modern stand of this variety of hickory about nine-tenths of a mile southeast of the village site.

There were no stone artifacts recovered except for one small triangular projectile point, fashioned from buff-colored chert, and two rejects of similar flint. A stone pestle (red granite) and mortar was found on floor level in the center of the house-pit. It seemed to have been used to break and grind flint into grit as an a-tempering for pottery, rather than to produce flour. Unusually large amounts of red and yellow hematite (ocher) covered the house floor. Its use has not been determined.

The clay industry was well represented by more than 680 pot sherds. A larger proportion of the pottery was found within the house walls, on the house floor, and in the eleven refuse pits. A smaller proportion was recovered outside of the walls. Inasmuch as the house-pits have been disturbed by cultivation and consequent erosion, no particular significance can be attached to pottery distribution except at floor level which was below the plough-line. Here, as in the pits, a careful analysis did not uncover any particular distribution pattern.

Of the total pottery—687 sherds—565 or 82 percent were plain sherds; 63 or 9 percent were decorated sherds; and 45 or 7 percent were rim sherds. Of the total sherds, 409 or 60 percent were a color which ranged from buff to orange-buff, and 270 or 39 percent were gray in color (not including the smoke stains). Both the gray and buff sherds were well mixed in both horizontal and vertical distribution. Of the non-decorative techniques, paddle-cord impression was predominant. Of the decorative techniques incision by "antler horn" was predominant with "thumb" impression following.

These decorative techniques are typical of the Upper-Mississippi pattern; for example, a thumb impression around the shoulder of the pot, or simple geometric motifs of parallel or curved lines. However there is *one* most significant exception: all of the sherds are Langford grit-temper with no known sherd containing Fisher shell-tempering. This should be noted with particular significance.

No human osseous material was recovered, although we recovered large amounts of animal and fish bones as well as clam shells. These have not been identified. None was fashioned into cultural objects. In

a brief account, the foregoing is a resumé of the type of objects recovered.

Problems

Although there are a number of problems suggested by the excavation, this paper considers only the problem of sequence based upon pottery tempering. It remains as one of the large problems at the Fisher site.

Does Langford grit-tempered precede, follow, or is it contemporary with Fisher shell-tempered ware? Or stating the problem as a cultural equation: What is the relation of Woodland culture pattern to the Upper-Mississippi culture pattern?

Discussion

Investigators George Langford and James B. Griffin, the latter basing his discussions on the notebooks of the former, established a sequence according to the levels inside of the mounds. According to them the upper level (the top of the mound) contained both shell-tempered and grit-tempered ware; below, there was shell-tempered ware but no grit-tempered ware. From their conclusions shell-tempered ware preceded grit-tempered ware at the Fisher site.

However Deuel (1940) as quoted by John Griffin (1944) felt that grit-tempered pottery preceded shell-tempered pottery, and according to John Griffin, Langford and J. B. Griffin interpreted the material incorrectly.[1]

John Griffin (1944), from a report of the pottery from house-pit 15, states: "that only Upper-Mississippi sherds were found within the house, in the wall trenches, and in the postholes." The aplastic isn't defined but we assume that the pottery of the two types is meant—shell and grit temper—and that these found together are typical "in part." House-pit 15 is quite near the West mound and is apparently contemporary with its upper level.

According to the conclusions of former archaeologists we have one of two choices in relation to house-pit 48: (1) Either the house-pit represents a pre-shell-temper or early culture manifestation; or (2) it represents a post-shell-temper or late culture manifestation.

Conclusions

Considering all of the traits diagnostic to the Upper-Mississippi pattern, evidence from the investigations of Langford and J. B. Griffin, and the added evidence of house-pit 48, it would certainly seem that shell-tempered pottery preceded grit-tempered pottery at the Fisher site. The sequence from bottom to top is:

3. grit
2. shell and grit
1. shell

This does not exclude the possibility of a very early Woodland culture, before the Mississippian, for this general area; it has not shown up yet at the Fisher site.

What can be inferred beyond this is difficult to say. House-pit 48 and the cluster of nine other house-pits seem to form a nucleus apart from the main village area built around the two large mounds according to the map published by the University of Chicago (1940) of the site. One notes that this smaller nucleus had

[1] Personal communication to the author from J. B. Griffin, 1946.

two small mounds of its own; the northwest and the north-northwest mounds. If this map is accurate (there are no recognizable traces of those mounds today), this group of house-pits apart from the main group, may well represent a later period for this part of Fisher site, with this section belonging to the Oneota aspect. However, one must be cautious in making generalities from pottery evidence alone.

A clarification of the movements of the proto-historic Woodland tribes from the East into this general area (Illinois) may help to clear some of the problems in conjunction with this site, particularly in connection with the seemingly strong late woodland culture penetration which may have caused the "Fisher people" to give up shell-tempering for grit-tempering.

Some of these problems may be solved if further excavations can be made in the "Woodland" section bordering the river area, as well as in the "historic village" section where sequence problems could be nailed down at this end of history.

None of these problems will be solved unless the archaeological work can be completed within the next five years. The present owner of the site, in line with his business —sand and gravel—will reduce this area, one of the most important sites in Northern Illinois, to a hole in the ground.

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THE SUCCESSION OF WOODLAND HORIZONS IN THE CARBONDALE AREA

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During the summers of 1938 and 1939 excavation was carried on by the Department of Anthropology of the University of Chicago at the Cove Hollow Rock Shelter in Jackson County, at the suggestion of Mr. Irvin Peithman of Carbondale.[1] At the close of the 1939 season excavations were continued on a twelve-month program until the fall of 1941 by the W.P.A. Museum Extension Project under the sponsorship of the Southern Illinois Normal University, the State Museum at Springfield, and the University of Chicago. Six village sites in Jackson and Williamson counties were excavated, and an extensive surface survey was made of these two counties. As a result of this work, evidence was found of an archaic pre-pottery culture, four stages of Woodland culture, and manifestations of the Middle Mississippi culture. This paper describes and interprets five of the six horizons thus established.

No component of the archaic pattern has been found in stratigraphic relationship with other cultures in the Carbondale region. However, a number of small open camp sites, with no depth of village debris, have yielded a distinctive complex of artifacts. This complex includes the bell-shaped pestle; nutting stones; bannerstones, or atlatl weights; caches of large, parallel-sided chert blades; long diagonal-notched projectile points; grooved axes, and possibly the hematite plummet. Typologically this complex equates with similar material found in situ and recognized as belonging to a pre-pottery horizon in the shell heaps of Indian Knoll in Kentucky, Wheeler Basin in Tennessee, and Pickwick Basin in Alabama.[2] More recently artifacts belonging to this complex have been found in Massac County at the Faulkner Site.[3] Here, a hunting and gathering group, using no pottery and hunting primarily with the atlatl and spear, definitely preceded the first pottery using group of the Baumer Focus. There is a close similarity between artifacts of the Faulkner Focus, and the camp site materials from the vicinity of Carbondale. As additional evidence, the only portion of a grooved axe to be found in the extensive excavations around Carbondale was found in the lowest level of the Crab Orchard village, underlying the oldest pottery type in the area.

The type site for the oldest focus in which pottery was present was the first village site excavated at Crab Orchard. Here, on a small knoll approximately two hundred yards from Crab Orchard Creek, was a small village originally covering roughly four hundred square feet. The village refuse, or midden, was a homogeneous black layer which extended downward from two to four feet, and which contrasted strongly with the yellow sterile clay

beneath it. Throughout the village area numerous round straight-sided pits with flat bottoms had been sunk one to two feet into the basic clay. Originally, in all probability, they were approximately three feet deep, and were utilized as storage pits. Later they apparently became receptacles for trash, many of them possibly remaining open for a number of years, from the evidence of pottery style changes represented in the refuse.

The pottery of this first Woodland complex, which has been called the Crab Orchard Focus, is rather distinctive, although it demonstrates a definite generic relationship with the pottery of the Baumer Focus in Massac and Pope counties.[4] The paste is thick, rather porous, and red to reddish-brown. The tempering material is uniformly crushed rock, quartzite, or feldspar, with temper particles ranging up to six mm. in size. In the lowest levels at Crab Orchard two forms of surface treatment appear to be associated with the same ware. The first is cord roughened, with long vertical single cord impressions, applied with a cord-wrapped paddle, or possibly rolled on with a cord-wrapped dowel. This type of surface treatment was apparently of short duration, and lasted only during the beginning phases of the Crab Orchard Focus. The second surface treatment consists of impressing the surface with a small segment of woven fabric, possibly a part of a plain plaited, or plain twined wicker basket. This gives the jar the appearance of having been formed inside a basket. However, the irregularity of the impressions and the fact that some jars show a vertical warp impression on the interior of the jar, indicate that a small woven mat was used in malleating the clay. Occasionally these impressions are made in imitation of the woven fabric by the use of a cord-wrapped dowel. This ware has been called Crab Orchard Fabric Marked.

The most common pottery shape in this focus is a long, conoidal jar with a slightly constricted neck and a flattened base. This flattened base is significant in that it appears to demonstrate a cultural relationship with the flat-based fabric-marked jars found at the Ledbetter Site in west Tennessee[5] and with flat based jars from Adena Sites.[6] The earlier flat bases are hardly functional, being only two inches in diameter for jars twenty or more inches in height. Later, the flat bases were increased to an average of six inches in diameter.

The projectile points belonging to the Crab Orchard Focus are predominantly large and broad, with slightly excurvate sides, straight shoulders, and small straight or slightly expanding tangs. Although not common, the most distinctive point for this period is small, with a small shallow notch, often on only one side, a straight parallel sided tang greater than half of the over-all length of the point, terminating in an excurvate base. Flake and core knives, scrapers, and chopping tools are common. A few small ovoid hoes were found, with the characteristic dirt polish on the blades. However, these were probably used to dig the numerous pits rather than in agricultural pursuits. Celts, which were rare, were short

and broad with irregularly tapering polls.

Although the stone artifacts overshadow the bone in numbers, a distinctive bone complex appears in the various components of this focus. This is significant, for due to soil conditions, no bone artifacts were recovered in the Baumer Focus to the south. Sharpened splinter awls of mammal and bird bone, and sharpened antler tines are common. Less common are deer metatarsal awls in which the joint has been utilized as a handle. Two large antler "drifts" or flaking hammers and one drilled handle were found. Although the antler projectile points actually found were rare, their relative frequency in the complex is apparent from the number of discarded antler blanks, which were cut in such a fashion that a tanged tine would be available for use as a projectile point. The four finished points which were found were uniformly long, with rather shallow sockets and triangular tangs. The sockets had been gouged out of the soft interior of the antler with a sharp tool.

As yet there has been no indication of house structure in connection with any of the Carbondale Woodland horizons. However, in the Baumer Focus, square houses were found,[7] and we may assume that semi-permanent houses were built in Crab Orchard Focus. Burials in the Crab Orchard Focus were of the bundle type, placed in irregular pits. There was evidence of the cremation of two infants in small round fire-pits.

The similarities between the Crab Orchard Focus in the first stage of its development and the Baumer Focus are quite marked. Surface treatment and vessel shape are alike, although Baumer pottery is predominantly limestone-tempered, whereas Crab Orchard is predominantly quartzite or feldspar. Projectile point types in both foci are similar. In particular one common type with weak shoulder, expanding or parallel-sided tang, and excurvate base demonstrates a link with the Adena of Kentucky.[8]

A second stage of development of the Crab Orchard Focus has been noted in a number of components along the Crab Orchard Creek. This is marked by the intrusion of Hopewell influences in the basic Crab Orchard Focus. Rim sherds of the type classified as Type 3 by Cole and Deuel[9] appear. Cut and drilled animal jaws and teeth; stone reel-shaped gorgets; round and diagonally notched projectile points; caches of ovate "hornstone" disks and fragments of unworked copper, galena, and mica are found in this level. It is significant to note that Hopewell did not supplant the Crab Orchard Focus, but merely added new elements to the basic culture. Hopewell design techniques were copied in the Crab Orchard ware, and we find cross-hatching and punctating of the rim and channel collars on Crab Orchard Fabric Marked jars. Zoned decoration, trailed and fine line incising, and punctate and dentate stamping are all present.

Recently a conical mound near the Mississippi River east of Carbondale has been found to contain a Hopewell burial. Here, on the Twenhofel Site, an extended burial was found, covered with a blanket of river pearls; two pairs of copper ear

spools; an ovate fluorspar gorget; armlets and wristlets of rectangular shell gorgets, and Illinois Hopewell and Crab Orchard Fabric Marked pottery. A surface survey of the adjacent village site showed a high percentage of Illinois Hopewell sherds and Crab Orchard Fabric Marked sherds.

Two interpretations of this situation can be made. Either a Hopewell group came down the Mississippi from the Illinois River center and settled on the Twenhofel Site, or the burial mound represents the ceremonial aspect of a highly influenced Crab Orchard Woodland group. Either possibility argues for the contemporaneity of Illinois Hopewell and Crab Orchard.

After the influence of Illinois Hopewell had waned, one ceramic trait, apparently introduced by the Hopewell culture, persisted in Crab Orchard pottery. This was the technique of punching a single or double row of holes parallel to the rim from the interior of the jar, producing a row of nodes around the exterior. This appears in Crab Orchard Fabric Marked and a later pottery type tentatively classified as Crab Orchard Cord Marked.

In the stratified Raymond Site, a second Woodland horizon appears in later levels above Crab Orchard material. This has been designated as the Raymond Focus. The similarity of this focus to the Lewis Focus in Massac and Pope counties is striking.[10] Both represent a meager culture with few artifacts, and in the case of the Raymond Focus, a decadence of ceramic technique.

The pottery is crude, with more or less straight sides and round bases. Occasionally the rim is punched and noded, and often the lip is notched. The vessel walls are much thinner than were those of the Crab Orchard wares, and the paste is harder. The temper appears to be equally a baked clay, or grit, with a considerable amount of sand included in the paste. The Crab Orchard pottery was formed by coiling but the Raymond pottery was made by the paddle and anvil method. The surface in every case was marked with single cords, presumably with a cord-wrapped paddle.

The predominant projectile point in this focus is a long slender point with a straight shoulder and a contracting tang. Knives are crude parallel-sided blades with a straight base. One long bar amulet, or atlatl weight, and three small ovoid celts were found. The bone complex includes only splinter awls and sharpened antler tips. No burials or houses were found which could be related to this focus.

The third Woodland group in the Carbondale area belongs to the Dillinger Focus. This manifestation, post-dating in stratified sites both Crab Orchard and Raymond, shows a strong combination of Middle Mississippi influences with an indigenous Woodland base. The contemporaneity of this focus with central and northern Illinois foci such as Maples Mills, Pere Marquette, and Jersey Bluff has been demonstrated, and the Dillinger Focus has been placed in the Tampico Phase of the Woodland Pattern.[11]

The pottery here is predominately grit-tempered and secondarily clay-grit tempered, with no sand included in the paste. The surface is cord

marked, with the impressions of tightly twisted cords running vertically to the shoulder. From the shoulder to the round base the cord impressions are checkered. The vessel forms in the Dillinger Cord Marked ware are more varied than the older Woodland forms. A large globular jar with a slightly constricted neck is the predominant shape. However, bowls and "salt pans" are frequent. A fillet is usually applied around the exterior of the rim, and the lip notched or raised to two or four lugs. Occasionally four to eight small nodes are added to the fillet at the lip in widely spaced groups. Two pottery variants are worthy of notice. The first is a small thick-walled conoidal tetrapodal vase, similar to fragments found on the surface of the village site at Cahokia in the Jersey Bluff Focus[12] and at the Pere Marquette Site.[13] The second is a small very thin-walled jar decorated with thin applied fillets which have been punctated. Other pottery artifacts were small dippers, a grit-tempered pottery trowel, an obtuse angle pipe, pottery disks, and a plummet-like object.

The stone complex also shows the weight of Mississippi influence. Although there are many of the large Woodland projectile points, the predominant form is a small unnotched, or side-notched triangle. Drills are small with expanded straight bases; flake knives are predominantly ovoid, and celts are thin, with parallel sides. Crude stone discoidals are present. In general the stone complex has been reduced in variety, and the bone complex expanded. Although splinter awls are common, the characteristic awl for the Dillinger Focus is a cut deer metatarsal, the joint serving for a handle. Bone chisels, antler punches, and bone fish hooks are common. Antler projectile points in this focus are significantly different from those found in the Crab Orchard Focus. They are much smaller, with ovate tangs, and the socket has been drilled and reamed, rather than gouged. Bone tallies cut from large bird bones are common. Tubular and flat bone beads are present but rare.

As in the earlier Woodland cultures, round flat-based pits had been dug throughout the village area. The refuse from these pits demonstrated a wide range of fauna, from the field mouse and mole to the wapiti. Occasional burned and cracked human femori indicated a possible cannibalism. Fish appeared to play a greater role in the diet of these people than of the earlier Woodland groups.

Although wattle and daub bricks were frequent in the refuse pits, there was no positive evidence of permanent houses. A survey along the Mississippi bluffs indicated that the dead of this focus were buried in slab box graves along the Mississippi. However, information regarding the burial complex must depend upon further excavation.

The exact position of the Dillinger Focus in regard to Middle Mississippi has not been determined. Ceramic traits and artifacts show a generalized Mississippi influence which cannot be related definitely to either Old Village, Trappist or Spoon River Foci. Recently Maples Mills and Old Village pottery were found in association, underlying a Spoon River component at the Gerren Site

in Fulton County.[14] This would indicate that the Dillinger Focus possibly preceeds the climax of Middle Mississippi development along the river. The Dillinger Focus may have persisted through the relatively short Middle Mississippi period. However, the absence of specialized Trappist or Spoon River traits would seem to make this questionable. Further information is needed on the ceremonial aspects of the focus. This will undoubtedly come from a more complete study of the burial complex along the Mississippi River bluffs.

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A SEVEN-POUND COPPER AXE AMONG 1946 HOPEWELL DISCOVERIES

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Four burials in a Fulton County mound, with their accompanying burial goods which include as an outstanding item, a 7-pound copper axe, are among the 1946 Hopewell discoveries of Mr. and Mrs. George Schoenbeck, members of Peoria Academy of Science, to be reported in this paper.

Other discoveries described briefly include material from three additional sites near the mound: a Hopewell village site, a Mississippi village site, and a Mississippi burial site. Recorded, also, as of interest, is another Hopewell find from the Steuben village site.

The first Fulton County discoveries were made September 22, 1946, when a fresh road-cut was investigated. The cut affected four adjacent sites, all of which had been previously recorded by Cole and Deuel in "Rediscovering Illinois,"[1] as among the mound and village sites of the general Sister Creeks group. These sites were designated as F° 60 (unit No. 60 in the Fulton County survey), a Hopewellian Mound; F^{v} 49, a Hopewellian village termed the Whitnah village; F^{v} 47, a Mississippian village; and F° 48, a Mississippian burial place.

Hopewell Mound

First, brief exploration was done at the Hopewell mound, considered the most important site, and results suggested there should be a full investigation. A report was made to Dr. Thorne Deuel, Director of Illinois State Museum, and work was withheld. At the other sites, all with material conspicuously exposed, some work was done.

After Dr. Deuel stated the museum could not undertake exploration of the mound and after road work had again exposed and destroyed still more material, the Schoenbecks, three weeks later, made a limited excavation. A few days after the excavating, more road work destruction occurred when a signpost was placed inside the face of the mound.

The large copper axe was one of five that accompanied the three original burials in the mound. Four of them, surrounded by bark as though wrapped in it and the bark preserved by the copper, occupied the same relative position, under the base of the skull, with the small end protruding to the left of the head. The fifth one was lower, possibly by the hand of the skeleton having the big axe.

All axes are covered with verdi gris, but exposed areas on the large one show a high polish. Each was but a part of the burial goods, which included several types of shell and pearl beads, cut human and animal jaws, worked bear canines, and stone gorgets. No Hopewell pipes, mica, copper other than the axes, Hopewell flint blades, or other chert arti-

[1] Cole, Fay-Cooper, and Deuel, Thorne, Rediscovering Illinois: Univ. of Chicago, 1937.

FIG. 1.—Hopewell mound in foreground, Hopewell village at base of bluff, Mississippian sites on bluff.

facts were found, though such might have been in the destroyed areas.

Weight of the large axe is seven pounds. Measurements are: length, 12⅝ inches or 32 centimeters; width of blade, 3¼ inches or 8.1 centimeters; width of poll, 1⅛ inches or 2.8 centimeters. Thickness at center is 1 inch or 2.4 centimeters.

The other four measure and weigh as follows:

Length (in.)	Blade width (in.)	Poll width (in.)	Weight
8	3¼	2	2½ lbs.
6½	2⅝	1¼	1 lb. 1 oz.
5⅛	2	¾	14 oz.
5½	2	1 5/16	11 oz.

Only the northwest quarter of the mound remains, the rest of it having been cut away by road building. Its two sloping cut faces, each with a ditch at base, meet at approximately the mound center, where the burials lay. A low remnant of the mound showed on the far side of the new road, from the east face, but it has since been buried under a fill. The south face measures about 40 feet and the east one about 60 feet, their exact outer ends being hard to determine. The mound height is about 6 feet above the burial floor.

In the east face appeared a very definite sloping black layer, 3 to 4 inches thick, which is possibly an old sod line on the top of an original mound. It showed for a length of 9 feet; its upper end was one foot below the present top, and the other was several feet lower and disappeared over the burial area. It suggested that the top of the original mound dropped over the general burial area and that a new top had been built up later.

First burial evidence was seen at the east end of the south face as a fairly distinct, gray horizontal line or layer, 1 to 1½ inches deep, extending westward about 9 feet, which suggested and later proved to be a floor. Small fragments of bone were in the ditch.

Shallow digging revealed three skeletons on the floor, with heads to the north, approximately, and a dug-in burial at a higher level and further west, with head to the east. There were amounts of white bone ash on an inclined area to the north of the burials, and lastly two de-

posits of remains on the other sides of the two ditches, which may, or may not, have been in original position.

Two of the three skeletons on the floor lay extended, but lower parts had been cut away at about the hip line by the road machinery. The third one, which lay to the right and west of the extended ones, was flexed and had been cut through just above the ankles. The skeleton of the higher, dug-in burial was flexed and, lying in an east-west direction behind the cut face, was undisturbed.

The floor was a layer of bark. This bark mass separated and broke away freely, offering a sharp cleavage line. Soil beneath the layer was a gray-brown mottled clay, and a higher level for this clay in the area north of the burials and ash suggests the bark floor was a sunken one. Soil covering the three skeletons was a black, dense, very hard soil like a gumbo or a swamp muck, so very hard when dried by the air as to seem impenetrable. No sand floor was located.

Bones were exceedingly soft. The combined extremes of hardness of soil and softness of bones made digging most difficult and caused more or less unavoidable destruction of burial material, particularly of bones.

Particles of white ash were seen on the east face immediately north of the head of the east skeleton and shallow digging exposed several irregular layer-like deposits of this ash. The layers sloped downward to the west but how far they extended is not known. Soil lay between the ash layers. No evidence of fire on the area, i.e. no baked soil, red-burned soil, charcoal or charred bone could be seen, though bits of charcoal were in the soil further north. The ash extends eastward across the ditch and suggests there may have been more burials there.

Some grave goods, part of which were found in the first shallow exploration and part found in the ditch following additional road work, have been tentatively assigned to two burials, according to location and other considerations. It was fortunate that the first items were obtained when they were because the later ditch work removed the front area of the mound.

The skeleton having the large axe lay extended upon its back, with the other extended one to its left and the flexed one to the right. Eighty barrel-shaped shell beads were around the neck and a portion of a perforated split bear canine, notched on inner edge, lay near them. This tooth was so tightly imbedded in the soil that it was brought out inside of a chunk of soil and extricated later. White material, possibly powdered shell beads, was inside the jaws, in the mouth. A piece of red ochre, a fragment of obsidian and one incised pottery sherd were in the soil.

Five copper-stained and copper-preserved pearl beads, one a 9/16 inch hemispherical one and the other four smaller cylindrical-shaped ones, were in the soil by lower left arm. Two more of the smaller beads were found later. The 11-ounce axe provided the stain on the beads and probably on another barrel-shaped bead found in ditch. Beside the axe were two large bear canines, each with two probably decorative perforations in the front and a complete

perforation in the top, probably for suspension. Lower on the arm were two small split bear canines, with notched edges perforated at the top, and bearing eight shallow decorative perforations arranged in two horizontal rows of four each. With these smaller canines were portions of eight cut and perforated human jaws, six left ones and two right ones. Here too was a portion of a human jaw with teeth, showing no cut, and a number of loose teeth.

By the right arm were two large bear canines, cut crosswise through the middle and beveled; at this cut the nerve canal showed enlargement into a perforation.

The skelton to the left lay in a similar position, but in a slightly NW-SE direction, with face turned to the left—the upper part more than the lower—and the lower jaw split up and down, suggesting weight and pressure and probably some movement of upper face. Pelvic bones were in place and vertebrae were in alignment.

Two copper axes, 6½ and 5⅛ inches long, were under the head, the larger one lower on the skull than the other. At the throat were 394 pearl and shell beads (made from columellae of marine shells) of varying size and shape. Two large perforated bear canines were, one on each side, under the jaw. Perforations consisted of two oblique ones in the face and a lengthwise one in top. Two notched and sharpened human canines were on the chest. The mouth of this skeleton also contained the white material, probably shell.

Fragments of a reel-shaped, perforated, gray shale[2] gorget lay in the soil, low on the body and close to the cut mound face, and other fragments were in the ditch. Twenty in all, they make almost a complete specimen. With the fragments in the ditch were fragments of another perforated gorget of white limestone,[2] extremely weathered and deteriorated by ground water action.

The flexed skeleton lay on its right side, in a NE-SW direction, but with head turned slightly to the left. A wide 8-inch 2½ pound axe was under the head. A portion of a perforated cut bear jaw with six jaw teeth lay east of the body, behind the back, at shoulder level. Lower leg bones protruded from the face of the mound.

The dug-in burial lay in an E-W position at a level about fifteen inches higher than the other burials and further to the west. The upper part of skeleton lay on its back, with head bent sharply forward onto chest. The skull was intact and in fair condition, better preserved than others. Teeth were well worn down. The occipital bone bore a very pronounced protuberance. Legs were bent, with knees high up and to the right of the pelvis. The skeleton gave the appearance of having been crowded into too small a hole. Sixteen split bear canines, 3 entire and 13 broken, one cut human jaw and a number of young teeth caps were imbedded in chest.

Pottery sherds found in outer mound soil and in ditches include Woodland Plain and Woodland Cord-roughened; thin leached Plain and Cord-roughened; Havana Zoned or Alternate Area; Incised; Dentate Stamped having horizontal band with plain band at top and incising

[2] Identified by Ruth Browne, Geology Instructor, Bradley University, Peoria, Ill.

and other with horizontal oblong teeth; gritty-tempered, wide-incised body similar to C. and D.'s No. 1 type; and Sister Creek Punctate in three variations.

Each of the small compact masses of burial material across the ditches seems to be isolated and may have been deposited there in a block by grader. The south one, which included a skull, lay at a depth below that of the bark floor in mound, so that if it were a burial it would have been a subfloor burial. Upper leg bones, which may belong to extended mound burials, and other bones are now weathering out of the soil on the road edge.

Hopewell Village

The Hopewell village lying on both sides of the new road going up the bluff, and extending well up the bluff face, has a freshly scraped area on the east side. From the village have been obtained perforated clam-shell hoes; a broken clay platform pipe; a cut perforated deer-bone game bone; clam shells; deer teeth; broken birdbone awl; drumhead mouth plate; grooved sharpening stone; pitted stones; otoliths; portion of limonite spade; worked fragment of turtle carapace; points and flake knives; chert scrapers; cut, hollowed, antler tip projectile point; celt fragment and many fish and other animal bones.

Around 100 rims and 86 lower rims and decorated sherds, including 5 Mississippi rims, have been collected. Represented are Naples Dentate Stamped; Crescent Dentate Stamped; Barred Ovoid Dentate Stamped; Woodland Plain with boss; Incurved Plain with sand tempering; Alternate Area or Havana Zoned; Incised; Hopewell Rocked and punctated rim; Bar stamped; Incised; Hopewell Crosshatched Rim; Imitation Hopewell Crosshatched; Sister Creek Punctate, some with boss; Clear Lake Corded-paddle-edge Stamped, both the heavy and the thin with wide-intervaled cord-roughening; and Maples Mills, or Cord Decorated (Gooden Cord Impressed).

The Maples Mills ware shows a later Woodland occupation than the Hopewell; the Mississippi sherds and a Mississippi pit dug down through the Hopewell village show a still later occupation. It is a stratified village site, with the Hopewell the strongest occupation.

Mississippian Burial Place

At the Mississippi burial place on bluff, simple burials were exposed well down the bluff slope. There was little burial goods. Bones were in excellent condition.

Mississippian Village

Pits of the Mississippi village were found on top of burials, to the north of them and to the south. One on the lower slope of bluff, dug down through the Hopewell village, was exposed in the wall of the west road-side ditch. A Mississippian globular bowl containing black soil and many fish and other fine bones, protruded from ditch wall at a 2½ foot depth below Hopewell village floor. Two other pits show on the ditch wall.

A horizontal burnt log, which a little digging showed to extend some distance, was located in the face of a side road-cut on the bluff, at a depth of 12 to 15 inches. Sherds and a portion of a small pot, a part weath-

FIG. 2.—Front and profile view of Steuben effigy.

ered out and a part remaining, were by it.

An item of interest from a pit above burials was a cut, hollow bird-bone containing another bone as fine as a darning needle and sharply pointed. Both were broken off together at one end, possibly by road machinery.

Considerable pottery was obtained from pits on bluff top. Included was a bowl with a bottom shaped like a wooden chopping bowl, topped by a very wide, flaring rim, decorated on inside, and flaring at about a 45° angle.

STEUBEN VILLAGE EFFIGY

Another Hopewell discovery, made May 5, 1946, is a carved and incised human head effigy of argillaceous sandstone[3] from the Steuben Village site located on the Illinois River, in Steuben township, Marshall County, about 23 miles north of Peoria.

The head is skillfully, effectively done.

It is a portion of some larger object, possibly a figurine, and measures in height 22 millimeters. Details offered by the effigy include the type of features and facial contour; the shape of the head and the shaved scalp; the elaborately ornamented or highly conventionalized ear; and the indication of some accouterment breaking the line between neck and left shoulder.

The site is recorded as site 22 in the Peoria Academy of Science Survey, copies of which are also in hands of University of Chicago and the Illinois State Museum. It is a sloping gravelly floodplain, lying on west bank of Illinois River, between

[3] Identified by Harold Lucy, head of Geology department, Bradley University, Peoria, Ill.

river and high bluff. Lower area is occasionally flooded and the whole is subject to very much erosion.

Abundant material has been exposed by cultivation for many years, particularly on several gravel ridges. Artifacts were excavated from a stratum exposed in the bank of a creek at a depth of over six feet. The stratum was immediately overlain by 4 inches of gravel. A portion of a human skeleton with bones in position and other material including shells, bones, etc. was found in the bed of the creek, at a slightly deeper level, likely of the same occupation period. These finds indicate that the creek, which now runs along the south side of the recognizable village area, did not exist in this particular location at the time of this occupation. Whether this deeper occupation level shows a buried sloping surface for the village now exposed on higher ground to the north or an earlier occupation has not yet been determined. The pottery dug out is Woodland.

The head was found on the freshly cultivated surface of the field following a plowing of increased depth which brought up a correspondingly increased amount of material. Most of the material was from a previously undisturbed depth as evidenced by an abundance of rotten, quickly deteriorating bones and shells, long depleted from the usual cultivation depth. A bird, of pink chert, is another effigy from this site.

BOTANY

R. O. FREELAND, *Chairman*
Northwestern University, Evanston

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1. Virginius H. Chase, Peoria Botanist: HARRY L. SPOONER, Peoria Historical Society, Peoria.

* 2. The Conspicuous Groups of Clavarioid Fleshy Fungi: MAXWELL DOTY, Northwestern University, Evanston.

3. Some Bryophytes of Coles and Clark Counties: CHARLES B. ARZENI, Charleston.

* 4. The True Irish Shamrock: JOHN B. MURPHY, DePaul University, Chicago.

5. The Control of Weeds on a Typical Prairie Farm: MARVIN R. SIBERT, London Mills High School, London Mills.

* 6. A New Species of Oedogonium from New Zealand: L. H. TIFFANY, Northwestern University, Evanton.

7. A Method for Cytological Investigation of Algae: CARROLL J. PETERSON, North Park College, Chicago.

* 8. The Growth of Conifers on Prairie Soil: RALPH W. LORENZ and J. NELSON SPAETH, University of Illinois Agricultural Experiment Station, Urbana.

* 9. Absorption of Streptomycin through the Root System and Its Transfer to Other Organs: O. D. MORGAN and H. W. ANDERSON, University of Illinois Agricultural Experiment Station, Urbana.

*10. A Decade of Experimenting with Colchicine: O. J. EIGSTI, Northwestern University, Evanston.

*11. Chromosome Studies by the Colchicine Pollen-tube Method: O. J. EIGSTI and CAROL SILVER, Northwestern University, Evanston.

*12. Chromosomal Morphology in Polygonatum: O. J. EIGSTI and JEANNE TOMHAVE, Northwestern University, Evanston.

*13. The Late Blight Problem: G. H. BOEWE, Illinois State Natural History Survey, Urbana.

*14. Carbon Dioxide Concentrations at Near-soil Levels of the Atmosphere of Illinois Forests and Grasslands: HARRY J. FULLER, University of Illinois, Urbana.

*15. The Use of Thermocouples in Soil Temperature Studies: MAX E. BRITTON, Northwestern University, Evanston.

16. Additions to the Check List of the Vascular Plants of Sangamon County, Illinois: GEORGE D. FULLER, Illinois State Museum, Springfield. (Read by title.)

17. *Houstonia minima* in Peoria County: E. SCHOENBECK, Peoria Academy of Science, Peoria.

18. The Acanthaceae of Illinois: GLEN S. WINTERRINGER, University of Illinois, Urbana.

19. A Revised Check List of the Vascular Plants of the University of Illinois Woodlands: G. NEVILLE JONES, University of Illinois, Urbana. (Read by title.)

*Not published.

SOME BRYOPHYTES OF COLES AND CLARK COUNTIES

CHARLES B. ARZENI
Eastern Illinois State Teacher's College, Charleston

Introduction

The following list of Bryophytes was compiled over a period of two and one half years. The sandstone outcrops on the banks of the Embarrass River, Fox Ridge State Park, and the hanging bogs east of Charleston have been the chief collecting grounds in Coles County. These areas provide various types of habitat—the bog-inhabiting *Riccardia pinguis* and *Campylium stellatum* may be found only a few steps from the xeric species of *Grimmia*. Many collections were taken from the mesophytic ravines and woods which are widespread in this area. It was interesting to find that the campus of the Eastern Illinois State Teacher's College contributed 51 species of *Musci* and four Hepatics, making a total of 55 species collected. Two of the mosses collected here are newly reported for the state.

Most of my collecting in Clark County was confined to the Rocky Branch area in the southeastern part of the county. This region is especially rich in Hepatics, and the sandstone banks provide 40 of the 42 liverworts reported. Three species of *Sphagna, Jungermannia, Trichocolea,* and a great number of *Musci* flourish here. The East-Central Illinois Bryophytes are probably best represented in this area.

At the 1934 Academy meeting, Miss Hague and Miss Stella Holmes (Barrick) presented a "List of the Bryophytes of Coles and Crawford Counties." Of the 31 mosses given in this list, I have not been able to collect *Climacium kindbergii* and *Amblystegiella confervoides.* I was unable to obtain packets of these. The *Brachythecium acutum* was incorrectly identified, and turned out to be *Leptodictyum riparium;* the *Mnium rostratum* (Schrad.) reported is *Mnium affine.* No species name was given for the *Polytrichum* in this check-list; however, the most common species in Coles County is *P. ohioense.*

R. H. Vaughan reported 72 mosses and 14 liverworts at the 1941 Academy meeting. This list appeared in the "Bryophytes of the Rocky Branch Region of Clark County, Illinois." I have been unable to collect *Hookeria acutifolia, Plectocolea crenuliformis, Mnium spinulosum, Brachythecium acutum, Fissidens viridulus,* and *Fissidens osmundioides,* which appeared in this list.

Of the 172 Bryophytes collected from Coles and Clark counties, 19 are newly reported for the state in this list. All the available literature on Illinois Bryophytes was referred to. Packets of these are deposited in the herbarium of the Eastern Illinois State Teacher's College, and in the author's personal collection. All the specimens have been checked by H. S. Conard, except the *Sphagna* which were checked by H. L. Blomquist.

I wish to express my thanks to H. S. Conard, H. L. Blomquist, A. J. Sharp, E. L. Stover, H. F. Thut, S. M. Hague, Mrs. F. E. Barrick, R. H.

Vaughan, E. Meadows, and the many other friends who helped me collect and packet material.

Names thus starred (*) are newly reported for Illinois in this list.

MUSCI

SPHAGNACEAE

**Sphagnum palustre* L. (Clark). Very common on moist sandstone banks beside stream.

**Sphagnum tenerum* Sull. & Lesq. (Clark). Common on the wet sandstone banks.

Sphagnum squarrosum Crome (Clark). Rare, and growing intermingled with *S. tenerum*. Reported collected in 1889 in the "Report of the Department of Natural History of Northwestern University." The only data given was that it was collected near Canton, Illinois.

TETRAPHIDACEAE

Tetraphis pellucida Hedw. (Coles, Clark).

POLYTRICHACEAE

Atrichum angustatum (Brid.) Bry. Eur. (Coles, Clark).

Atrichum undulatum (Hedw.) Beauv. (Coles, Clark).

Pogonatum pensilvanicum (Hedw.) Paris. (Coles, Clark).

Polytrichum commune Hedw. (Coles, Clark). Rare on hillsides in woods.

Polytrichum juniperinum Hedw. (Clark, Coles). Not common, on dry soil.

Polytrichum ohioense Ren. & Card. (Coles, Clark). Very common.

Polytrichum piliferum Hedw. (Clark). Rare and sterile; dry soil.

FISSIDENTACEAE

Fissidens cristatus Wils. (Clark, Coles).

Fissidens exiguus Sull. (Coles, Clark).

Fissidens minutulus Sull. (Coles, Clark).

Fissidens obtusifolius Wils. (Coles, Clark). Common on partly submerged rocks in Embarrass River. As far as I know, the only other report for this moss in the state was by Wolf in Fulton county.

Fissidens osmundioides Hedw. (Clark). Reported by R. H. Vaughan in Clark county. I have not collected it.

Fissidens subbasilaris Hedw. (Coles, Clark).

Fissidens taxifolius Hedw. (Coles, Clark).

Fissidens viridulus (Web. & Mohr) Wahlenb. Reported for Clark county by R. H. Vaughan.

DITRICHACEAE

Ceratodon purpureus (Hedw.) Brid. (Coles, Clark).

Ditrichum pallidum (Hedw.) Hampe (Coles, Clark).

Ditrichum pusillum (Hedw.) E. G. Britton (Coles, Clark).

Pleuridium subulatum (Hedw.) Lindb. (Coles, Clark).

DICRANACEAE

Brothera Leana (Sull.) C. Mull. (Coles). Reported previously by Wolf & Hall in Fulton and Menard counties, and by Drexler in Champaign county.

Dicranella heteromalla (Hedw.) Schimp. (Coles, Clark).

Dicranella rufescens (Smith) Schimp. (Coles, Clark).

Dicranella varia (Hedw.) Schimp. (Coles, Clark).

Dicranum flagellare Hedw. (Clark. Very rare on moist soil along stream bank at Rocky Branch.

Dicranum scoparium Hedw. (Coles, Clark).

Dicranum rugosum (Hoffm.) Brid. This is *D. undulatum* (Ehrh.) Sturm. Very rare in Clark county.

LEUCOBRYACEAE

Leucobryum glaucum (Hedw.) Schimp. (Coles, Clark).

BUXBAUMIACEAE

Diphyscium foliosum (Hedw.) Mohr. (Coles, Clark).

POTTIACEAE

Barbula fallax Hedw. (Coles, Clark).

Barbula unguiculata Hedw. (Coles, Clark).

Desmatodon obtusifolius (Schwaegr.) Jur. (Coles, Clark).

Desmatodon Porteri James (Coles, Clark). Not common, on dry sandstone rocks.

Didymodon recurvirostris (Hedw.) Jennings (Coles, Clark).

Gymnostomum calcareum Nees & Hornsch. (Clark).

Tortella humilis (Hedw.) (Coles, Clark).

Tortula mucronifolia Schwaegr. (Coles, Clark).

Weisia viridula Hedw. (Coles, Clark).

GRIMMIACEAE

Grimmia apocarpa Hedw. (Coles, Clark).

**Grimmia laevigata* (Brid.) Brid. (Clark). Rare on dry sandstone banks at Rocky Branch.

Hedwigia ciliata Hedw. (Coles, Clark).

EPHEMERACEAE

Ephemerum crassinervinum (Schwaegr) C. Mull. (Coles, Clark). Common among the cattails at the edge of ponds.

**Ephemerum spinulosum* Schimp. (Coles, Clark). Common on moist soil in fields and at the edge of streams.

**Ephemerum spinulosum* var. *hystrix* (Lindb.) Grout (Coles). Not common, and growing intermingled with the previous plants.

**Ephemerum spinulosum* var. *Texanum* Grout (Coles). Rare and growing with *E. spinulosum*. Fruiting material taken from the wet mud around the campus lake, Eastern Illinois State Teacher's College.

FUNARIACEAE

Aphanorhegma serratum (Hook. & Wils.) Sull. (Coles, Clark).

Funaria hygrometrica Hedw. (Coles, Clark).

Physcomitrium turbinatum (Mx.) Brid. (Coles, Clark).

ORTHOTRICHACEAE

Drummondia prorepens (Hedw.) Jennings (Coles, Clark). On the bark of maples—not common.

Orthotrichum ohioense Sull. & Lesq. (Coles). Not common on the bark of white oak.

Orthotrichum pumilum Dicks. (Coles, Clark). Very common in both counties.

Orthotrichum strangulatum Schwaegr. (Coles, Clark). Not common on dry rocks.

TIMMIACEAE

Timmia megapolitana Hedw. (Clark). Not common.

AULACOMNIACEAE

Aulacomnium heterostichum (Hedw.) Bry. Eur. (Coles, Clark).

Aulacomnium palustre (Web. & Mohr) Schwaegr. (Clark). Rare along shaded stream banks.

BARTRAMIACEAE

Bartramia pomiformis Hedw. (Coles, Clark).

BRYACEAE

Bryum argentum (L.) Hedw. (Coles, Clark).

Bryum caespiticium (L.) Hedw. (Coles, Clark).

Bryum pendulum (Hornsch.) Schimp. (Clark). Not common on sandstone rocks.

Bryum pseudotriquetrum (Hedw.) Schwaegr. (Coles, Clark).

Leptobryum pyriforme (Hedw.) Schimp. (Coles, Clark).

Pohlia nutans (Hedw.) Lindb. (Coles, Clark).

Pohlia Wahlenbergii (Web. & Mohr) Andrews (Coles, Clark). Plants collected in Coles county producing antheridial heads.

Rhodobryum roseum (Bry. Eur.) Limpr. (Coles, Clark).

MNIACEAE

Mnium affine Bland. (Coles, Clark).

Mnium affine var. *rugicum* B & S (Coles, Clark).

Mnium cuspidatum Hedw. (Coles, Clark).

Mnium punctatum Hedw. (Coles, Clark).

Mnium serratum Brid. (Coles, Clark).

Mnium spinulosum Bry. Eur. Reported at Rocky Branch, Clark county by R. H. Vaughan. I have not collected it.

HYPNACEAE

Amblystegiella confervoides (Brid.) Loeske. Reported for Coles county by Miss Hague and Miss S. Holmes (Barrick).

Amblystegium compactum (C. Mull.) Aust. (Clark). Not common in stream bed.

Amblystegium Juratzkanum Schimp. (Clark).

Amblystegium serpens (Hedw.) Bry. Eur. (Coles, Clark).

Amblystegium varium (Hedw.) Lindb. (Coles, Clark).

Brachythecium acutum (Mitt.) Sull. Reported in Clark county by R. H. Vaughan.

Brachythecium flagellare (Hedw.) Jennings (Coles, Clark). Common on shaded banks.

Brachythecium oxycladon (Brid.) Jaeger & Sauerb. (Coles, Clark).

Brachythecium oxycladon var. *dentatum* (Lesq. & James) Grout (Clark). Common on moist soil; preferring stream banks.

Brachythecium rivulare Bry. Eur. (Clark).

Brachythecium salebrosum (Web. & Mohr) Bry. Eur. (Coles, Clark).

**Brotherella recurvans* (Mx.) Fleisch. (Coles, Clark). Not common on rotten logs at Fox Ridge State Park.

Bryhnia graminicolor (Brid.) Grout (Clark, Coles).

Calliergonella cuspidata (Brid.) Loeske (Clark, Coles). Rare in hanging bogs.

Calliergonella Schreberi (Bry. Eur.) Grout (Coles, Clark).

Campylium chrysophyllum (Brid.) Bryhn (Coles, Clark).

**Campylium chrysophyllum* var. *brevifolium* (Ren. & Card.) Grout (Clark). Common on moist banks. Leaves all swept to one side.

Campylium hispidulum (Brid.) Mitt. (Coles, Clark).

Campylium stellatum (Hedw.) Lange & C. Jens. (Coles). Rare in hanging bogs at "Foltz's".

Chamberlainia acuminata (Hedw.) Grout (Coles, Clark).

Cirriphyllum Boscii (Schwaegr.) Grout (Coles, Clark).

Climacium americanum Brid. (Coles, Clark).

Climacium Kindbergii (Ren. & Card.) Grout. Reported by Miss S. Hague and Miss S. Holmes (Barrick) for Coles county.

Cratoneuron filicinum (Hedw.) Roth (Coles, Clark). Not common on old logs and in bogs. Bog plants without paraphyllia!

Entodon cladorrhizans (Hedw.) C. Mull. (Coles, Clark).

Endodon compressus (Hedw.) C. Muell. (Coles, Clark).

Eontodon seductrix (Hedw.) C. Muell. (Coles, Clark).

Eurhynchium hians (Hedw.) Jaeger & Sauerb. (Coles, Clark).

Eurhynchium serrulatum (Hedw.) Kindb. (Coles, Clark).

Heterophyllium Haldanianum (Grev.) Kindb. (Coles, Clark).

Homomallium adnatum (Hedw.) Broth (Coles, Clark).

Hygroamblystegium fluviatile (Hedw.) Loeske (Clark).

Hygroamblystegium irriguum (Wils.) Loeske (Coles, Clark).

Hygroamblystegium orthocladon (Beauv.) Grout (Coles, Clark).

Hypnum curvifolium Hedw. (Coles, Clark). Common at Rocky Branch.

Hypnum imponens Hedw. (Clark). Rare on moist soil.

Hypnum Patientiae Lindb. (Coles, Clark). Very common everywhere.

**Hypnum reptile* Mx. (Clark). Rare on rotten logs.

Leptodictyum riparium (Heaw.) Warnst. (Coles, Clark).

Leptodictyum riparium forma *flaccidum* (L & J) (Coles). Growing submerged; capsules taken in January.

Leptodictyum trichopodium (Schultz) Warnst. (Coles, Clark).

Plagiothecium denticulatum (Hedw.) Bry. Eur. (Clark).

Plagiothecium geophilum (Aust.) Grout (Clark). Not common on the moist soil along stream.

Plagiothecium Roeseanum (Hampe) Bry. Eur. (Clark). Rare at Rocky Branch.

Plagiothecium deplanatum (Sull.) Grout (Coles, Clark). Not common in crevices in the sandstone banks.

Platygyrium repens (Brid.) Bry. Eur. (Coles, Clark).

Sematophyllum carolinianum (C. Muell.) E. G. Britton (Coles, Clark). As far as I know, this is the second report for this moss in Illinois.

LESKEACEAE

Anomodon attenuatus (Hedw.) Huben. (Coles, Clark).

Anomodon minor (Beauv.) Lindb. (Coles, Clark).

Anomodon rostratus (Hedw.) Schimp. (Coles, Clark).

Leskea obscura Hedw. (Coles, Clark).

Leskea polycarpa Hedw. (Coles, Clark).

Leskea gracilescens Hedw. (Coles, Clark).

Lindbergia brachyptera var. *Austinii* (Sull.) Grout (Coles, Clark).

Thelia asprella Sull. (Coles, Clark).

**Thuidium abietinum* (Brid.) Bry. Eur. (Clark). Rare on dry soil.

Thuidium delicatulum (Hedw.) Mitt. (Coles, Clark).

Thuidium pygmaeum Bry. Eur. (Clark).

Thuidium recognitum (Hedw.) Lindb. (Coles, Clark).

Thuidium virginianum (Brid.) Lindb. (Coles, Clark).

HOOKERIACEAE

Hookeria acutifolia Hook. Reported at Rocky Branch by R. H. Vaughan.

LEUCODONTACEAE

Leptodon trichomitrion (Hedw.) Mohr (Coles, Clark).

Leucodon julaceus (Hedw.) Sull. (Coles, Clark).

**Leucodon brachypus* Brid. (Coles). Rare on bark of trees.

FABRONIACEAE

**Fabronia Ravenelli* Sull. (Coles). Not common on the bark of white oak in moist woods.

HEPATICAE

PTILIDIACEAE

Ptilidium pulcherrimum (Web.) Hampe (Coles, Clark). Not common on rotten logs along sides of ravines.

Blepharostoma trichophyllum (L.) Dumort. (Coles, Clark). Very abundant at Rocky Branch on sandstone.

**Tricholea tomentella* (Ehrh.) Dum. (Clark). Common on the moist banks along stream.

LEPIDOZIACEAE

**Bazzania trilobata* (L.) S. F. Gray (Clark). Very rare on the sandstone banks.

**Lepidozia reptans* (L.) Dumort. (Clark). Rare on rotten logs.

CALYPOGEIACEAE

Calypogeia Trichomanis (L.) Corda (Coles, Clark).

CEPHALOZIACEAE

Cephalozia connivens (Dicks.) Lindb. (Coles, Clark). Common on moist, rotten logs.

Cephalozia media Lindb. (Clark). Common on shaded sandstone.

Nowellia curvifolia (Dicks.) Mitt. Rare on rotten wood at Rocky Branch.

HARPANTHACEAE

Lophocolea heterophylla (Schrad.) Dumort. (Coles, Clark).

Lophocolea minor (Lehm.) Nees (Clark). Rare on soil and old wood.

Harpanthus scutatus (Web. & Mohr) Spruce (Clark). Not common, and growing intermingled with *Cephalozia media* and *Blepharostoma trichophyllum.*

JUNGERMANNIACEAE

**Lophozia incisa* (Schrad.) Dum. D'Obs. (Clark). Common on the moist sandstone banks, and growing with *Plectocolea.*

Jungermannia lanceolata L. (Coles, Clark). Not common, and growing among the *Sphagna.*

**Plectocolea crenulata* (Smith) Evans (Clark). Not common on the moist soil on sandstone banks.

**Plectocolea crenuliformis* (Aust.) Mitt. Reported at Rocky Branch by R. H. Vaughan.

Plectocolea hyalina (Lyell) Mitt. (Clark). Not common.

Plectocolea fossombronioides (Aust.) Mitt. As far as I know, this is the second report for the state. Not common at Rocky Branch.

PLAGIOCHILACEAE

Plagiochila asplenioides (L.) Dumort. (Clark, Coles).

SCAPANIACEAE

Scapania nemorosa (L.) Dumort. (Clark, Coles).

PORELLACEAE

Porella platyphylloidea (Schwein.) Lindb. (Clark, Coles).

RADULACEAE

Radula complanata (L.) Dumort. (Coles, Clark). Not common at the base of trees.

FRULLANIACEAE

Frullania Asagrayana Mont. (Coles). Rare on the bark of white oak.

Frullania eboracensis Gottsche. (Coles, Clark).

Frullania inflata Gottsche. (Coles, Clark).

Frullania riparia Hampe (Coles, Clark). Common on moist sandstone.

Frullania squarrosa (R. Bl. & N.) Dumort. (Clark). On shaded banks; preferring moist sandstone. Common.

LEJEUNEACEAE

**Lejeunea cavifolia* (Ehrh.) Lindb. (Clark). Rare on rotten wood.

PELLIACEAE

Pellia epiphylla (L.) Corda (Coles, Clark). Very common on moist soil and rocks.

BLASIACEAE

Blasia pusilla L. (Clark). Very common on sandy soil.

RICCARDIACEAE

Riccardia pinguis (L.) S. F. Gray (Coles). Not common among the cattails in hanging bogs.

MARCHANTIACEAE

Marchantia polymorpha L. (Coles, Clark).

Preissia quadrata (Scop.) Nees (Clark). Not common on sandstone rocks.

Conocephalum conicum (L.) Dumort. (Coles, Clark).

REBOULIACEAE

Reboulia hemisphaerica (L.) Raddi (Coles, Clark).

Mannia fragrans (Balb.) Frye & Clark (Clark). Common at Rocky Branch.

Asterella tenella (L.) Beauv. (Coles, Clark). Common on dry soil.

RICCIACEAE

Riccia fluitans L. (Coles, Clark). Not common on moist soil along river bank.

Ricciocarpus natans (L.) Corda (Coles, Clark). Not common on moist soil.

ANTHOCEROTACEAE

Anthoceros laevis L. (Coles, Clark). Common on clayey soil.

**Anthoceros crispulus* (Mont.) Douin (Clark). Common on wet rocks.

Notothylas orbicularis (Schwein.) (Coles, Clark). Common on moist soil.

ADDITIONS TO THE FLORA OF SANGAMON COUNTY, ILLINOIS

GEORGE D. FULLER
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In 1943 a check list of the vascular plants of Sangamon County was published (1) in which some 870 species were named. Now it seems desirable to make certain corrections and additions to the list, especially since there appeared in 1945 a Flora of Illinois by G. Neville Jones (2). During the past five years at least 40 additional species have been collected in the county. Mrs. Lola Carter has been particularly active in this field and has added a dozen species to the Springfield area. Notable among these are the rare fern, *Woodsia obtusa*, the little rattle-box *Crotalaria sagittalis* and two rare thistles, the Hill's thistle, *Cirsium hillii* and the tall wood thistle, *Cirsium altissimum*. Members of the Nature League of Springfield have contributed several species, some of which are rather rare.

Norman Reeder, an amateur botanist and a specialist in the grass family, has revised and corrected the list of grasses and has added 20 species, some of them rare in Illinois. A similar revision of the sedge family would be desirable and it would add many species to the flora of the county.

A further study of several species has made it necessary to drop a few species and to rectify a few erroneous determinations. The present results seem to show that there are 912 known species of vascular plants growing in Sangamon County and indicate that the total flora of the county will not fall much short of a thousand species.

Polypodiaceae
Pteridium latisculum (Desv.) Hieron.
Woodsia obtusa (Spreng.) Torr.
Typhaceae
Typha angustifolia L.
Alismaceae
Sagittaria brevirostra Mack. & Bush
Gramineae
Festuca elatior L.
Festuca obtusa Spreng.
Poa chapmaniana Scribn.
Poa nemoralis L.
Poa palustris L.
Poa sylvestris Gray
Agropyron smithii Rydb.
Sphenopholis obtusata (Michx.) Scribn.
Danthonia spicata (L.) Beauv.
Agrostis hyemalis (Walt.) BSP.
Alopecurus carolinianus Walt.
Muhlenbergia schreberi Gmel.
Muhlenbergia sobolifera (Muhl.) Trin.
Sporobolus asper (Michx.) Kunth.
Sporobolus cryptandrus (Torr.) Gray
Sporobolus neglectus Nash.
Paspalum pubescens Muhl.
Panicum lanuginosum Ell.
Panicum tennesseense Ashe
Setaria verticillata (L.) Beauv.
Cenchrus pauciflorus Benth.
Andropogon virginicus L.
Sorghum halepense (L.) Pers.
Cyperaceae
Cyperus houghtonii Torr.
Araceae
Acorus calamus L.
Juncaceae
Juncus torreyi Cov.
Betulaceae
Corylus americana Walt.
Amaranthaceae
Froelichia campestris Small
Polygonaceae
Rumex obtusifolius L.
Elatinaceae
Elatina brachysperma Gray
Ranunculaceae
Ranunculus sceleratus L.
Ranunculus flabellaris Raf.

Cruciferae
Alliaria officinalis Andrez.
Rosaceae
Instead of
Geum macrophyllum read
Geum laciniatum Murr.
Leguminoseae
Crotolaria sagittalis L.
Umbelliferae
Erigenia bulbosa (Michx.) Nutt.
Primulaceae
Aster tataricus L.
Asclepiadaceae
Asclepias tuberosa L.
Convolvulaceae
Cuscuta cephalanthi Engelm.
Labiatae
Lamium purpureum L.
Scutellaria ambigua Nutt.
Compositae
Aster tataricus L.
Antennaria neglecta Greene
Carduus nutans L.
Cirsium altissimum (L.) Spreng.
Cirsium hillii (Canby) Fern.
Helianthus tuberosus L.

The following species have been reported as occurring in Sangamon County but careful search has failed to find them.

Sanicula trifoliata Bickn.
Hydrophyllum macrophyllum Nutt.
Lobelia kalmii L.
Anaphalis margaritacea Gray
Iva xanthifolia Nutt.

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A REVISED CHECKLIST OF THE VASCULAR PLANTS OF THE UNIVERSITY OF ILLINOIS WOODLANDS

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It is nearly five years since the publication of the first checklist of the vascular plants of the University woodlands,[1] and copies of that list are no longer available. Therefore it seems desirable at this time to present a new and revised list.

The University of Illinois woodlands, situated a few miles northeast of Urbana, Champaign County, Illinois, consist of approximately 100 acres of natural woods, fenced and maintained by the University of Illinois as a permanent preserve of wild life for scientific purposes. This property consists of two separate areas about one mile apart, the Brownfield Woods, and the Trelease (formerly University) Woods.

The following checklist is based chiefly upon the collections of the writer during the years 1939 to 1947. The specimens upon which the records are based have been deposited in the Herbarium of the University of Illinois. A few other species not included in this list have been attributed to these woodlands, but since reports of these plants are not based upon specimens they have been left out. The present revision includes the names of the families as well as common names for most of the species. It includes 274 species in 189 genera and 76 families.

[1] Transactions of the Illinois State Academy of Science 35: 71-72 (1942).

Division I. Pteridophyta.
Ferns and Fern-allies

Ophioglossaceae Presl—Adder's-tongue Family

Botrychium virginianum (L.) Sw.—Rattlesnake Fern.

Polypodiaceae R.Br.—Fern Family

Athyrium pycnocarpon (Spreng.) Tidestr.—Glade Fern

Cystopteris fragilis (L.) Bernh.—Brittle Fern

Division II. Spermatophyta.
Seed Plants

Subdivision II. Angiospermae. Flowering Plants

Class I. Monocotyledoneae

Gramineae Juss.—Grass Family

Bromus tectorum L.—Cheat

Cinna arundinacea L.—Wood Reed Grass

Dactylis glomerata L.—Orchard Grass

Diarrhena americana Beauv.

Digitaria Sanguinalis (L.) Scop.—Common Crab Grass

Echinochloa crusgallii (L.) Beauv.—Barnyard Grass

Elymus villosus Muhl.—Slender Wild Rye

Eragrostis cilianensis (All.) Link—Stink Grass

Festuca obtusa Spreng.—Nodding Fescue

Glyceria striata (Lam.) Hitchc.—Meadow Grass

Hystrix patula Moench.—Bottlebrush Grass

Leersia virginica Willd.—White Grass

Muhlenbergia mexicana (L.) Trin.—Wirestem Grass

Muhlenbergia scherberi J. F. Gmel.—Nimble Will

Panicum capillare L.—Witch Grass

Panicum dichotomiflorum Michx.—Spreading Witch Grass

Phleum pratense L.—Timothy

Poa compressa L.—Canada Blue Grass

Poa pratensis L.—Kentucky Blue Grass

Poa sylvestris A. Gray—Woodland Blue Grass

Setaria lutescens (Weig.) F. T. Hubb.—Yellow Foxtail

Sporobolus heterolepis A. Gray—Sand Dropseed
Sporobolus vaginiflorus (Torr.) Wood —Sheathing Dropseed

Cyperaceae J.St.Hil.—Sedge Family
Carex albursina Sheld.
Carex blanda Dewey
Carex bromoides Schkuhr.
Carex gravida Bailey
Carex grayii Carey
Carex grisea Wahl.
Carex hirtifolia Mack.
Carex rosea Schkuhr.

Araceae Necker—Arum Family
Arisaema atrorubens (Ait.) Bl.—Jack-in-the-Pulpit. Indian Turnip
Arisaema dracontium (L.) Schott—Green Dragon. Dragonroot

Commelinaceae Reichenb.—Spiderwort Family
Tradescantia subaspera Ker—Spiderwort

Juncaceae Vent.—Rush Family
Juncus tenuis Willd.

Liliaceae Adans.—Lily Family
Allium canadense L.—Wild Garlic
Allium tricoccum Ait.—Wild Leek
Asparagus officinalis L.—Asparagus
Erythronium albidum Nutt.—White Trout-lily
Lilium michiganense Farw.—Wild Lily
Polygonatum pubescens (Willd.) Pursh. —Solomon's-seal
Smilacina racemosa (L.) Desf.—Large False Solomon's-seal
Smilacina stellata (L.) Desf.—Small False Solomon's seal
Smilax ecirrhata (Engelm.) Wats.—Upright Smilax
Smilax hispida Muhl.—Common Greenbrier
Smilax lasioneuron Hook.—Carrion Flower
Trillium gleasoni Fern.—White Trillium
Trillium recurvatum Beck—Purple Trillium
Uvularia grandiflora Sm.—Bellwort

Iridaceae Lindl.—Iris Family
Iris shrevei Small—Iris

Orchidaceae Lindl.—Orchid Family
Aplectrum hyemale (Muhl.) Torr.—Puttyroot
Orchis spectabilis L.—Showy Orchis
Triphora trianthophora (Sw.) Rydb.—Nodding Pogonia

Class II. **Dicotyledoneae** Juss.

Salicaceae Lindl.—Willow Family
Populus deltoides Marsh.—Cottonwood
Betulaceae Agardh.—Birch Family
Carpinus caroliniana Walt.—Muscle Tree
Ostrya virginiana (Mill.) K.Koch—Ironwood
Corylus americana Walt.—Hazel

Juglandaceae Lindl.—Walnut Family
Juglans cinerea L.—Butternut
Juglans nigra L.—Black Walnut
Carya cordiformis (Wang.) K.Koch—Yellowbud Hickory
Carya ovata (Mill.) K. Koch—Shagbark Hickory
Carya laciniosa (Michx.f.) Loud.—Big Shagbark Hickory

Fagaceae A.Br.—Beech Family
Quercus bicolor Willd.—Swamp White Oak
Quercus imbricaria Michx.—Shingle Oak
Quercus macrocarpa Michx.—Bur Oak
Quercus muhlenbergii Engelm.—Chinquapin Oak
Quercus rubra L.—Red Oak (*Q. borealis* Michx.f.)

Ulmaceae Mirb.—Elm Family
Celtis occidentalis L.—Hackberry
Ulmus americana L.—American Elm
Ulmus fulva Michx.—Slippery Elm

Moraceae Lindl.—Mulberry Family
Maclura pomifera (Raf.) Schneid.—Osage-orange. Hedge-apple
Morus alba L.—White Mulberry
Morus rubra L.—Red Mulberry

Cannabinaceae Lindl.—Hemp Family
Humulus americanus Nutt.—American Hop
Cannabis sativa L.—Common Hemp. Marijuana

Urticaceae Reichenb.—Nettle Family
Urtica procera Muhl.—Common Nettle
Laportea canadensis (L.) Gaud.—Wood Nettle
Parietaria pennsylvanica Muhl.—Pellitory
Pilea pumila (L.) A.Gray—Clearweed

Aristolochiaceae Blume—Birthwort Family
Asarum reflexum Bickn.—Wild Ginger

Polygonaceae Lindl.—Buckwheat Family
Polygonum pennsylvanicum L.—Smartweed
Polygonum persicaria L.—Lady's Thumb
Polygonum punctatum Ell.—Water Smartweed
Polygonum scandens L.—Climbing False-buckwheat
Polygonum virginianum L.—Virginia Knotweed

Rumex acetosella L.—Field Sorrel. Sour Dock
Rumex crispus L.—Curly Dock

Chenopodiaceae Dum.—Goosefoot Family
Chenopodium album L.—Lamb's Quarter
Chenopodium standleyanum Aellen (*C. boscianum* of auth.)

Amaranthaceae J.St.Hil.—Amaranth Family
Amaranthus retroflexus L.—Rough Pigweed

Phytolaccaceae Lindl.—Pokeweed Family
Phytolacca americana L.—Pokeweed

Portulacaceae Reichenb.—Purslane Family
Claytonia virginica L.—Spring Beauty

Caryophyllaceae Reichenb.—Pink Family
Cerastium vulgatum L.—Common Mouse-ear Chickweed
Silene antirrhina L.—Sleepy Catchfly
Silene stellata (L.) Ait.—Starry Catchfly
Stellaria media (L.)—Vill.—Common Chickweed

Annonaceae DC.—Custard-apple Family
Asimina triloba (L.) Dunal—Pawpaw

Ranunculaceae Juss.—Buttercup Family
Actaea alba (L.) Mill.—White Baneberry. Doll's Eyes
Anemone canadensis L.—Meadow Anemone
Anemone virginiana L.—Tall Anemone
Hepatica acutiloba DC.—Hepatica
Hydrastis canadensis L.—Goldenseal
Isopyrum biternatum (Raf.) T.&G.—False Rue-anemone
Ranunculus abortivus L.—Small-flowered Buttercup
Ranunculus septentrionalis Poir.—Marsh Buttercup
Thalictrum dioicum L.—Early Meadow-rue
Thalictrum revolutum DC.—Waxy Meadow-rue

Berberidaceae T.&G.—Barberry Family
Caulophyllum thalictroides (L.) Michx.—Blue Cohosh
Podophyllum peltatum L.—May-apple. Mandrake

Menispermaceae DC.—Moonseed Family
Menispermum canadense L.—Moonseed

Lauraceae Lindl.—Laurel Family
Lindera benzoin (L.) Bl.—Spice-bush

Papaveraceae B.Juss.—Poppy Family
Sanguinaria canadensis L.—Bloodroot

Fumariaceae DC.—Fumitory Family
Dicentra canadensis (Goldie) Walp.—Squirrel-corn
Dicentra cucullaria (L.) Bernh.—Dutchman's-breeches

Cruciferae B.Juss.—Mustard Family
Barbarea vulgaris R.Br.—Wintercress
Capsella bursa-pastoris (L.) Medic.—Shepherd's Purse
Cardamine bulbosa (Schreb.) BSP.—Bulbous Cress
Cardamine douglassii (Torr.) Britt.—Purple Cress
Dentaria laciniata Muhl.—Toothwort
Iodanthus pinnatifidus (Michx.) Steud.
Lepidium virginicum L.—Common Peppercress

Grossulariaceae Dum.—Gooseberry Family
Ribes americanum Mill.—American Black Currant
Ribes missouriense Nutt.—Missouri Gooseberry

Platanaceae Lindl.—Plane-tree Family
Platanus occidentalis L.—Sycamore

Rosaceae Juss.—Rose Family
Agrimonia pubescens Wallr.—Agrimony
Crataegus crusgalli L.—Cockspur Thorn
Crataegus mollis (T.&G.) Scheele
Fragaria virginiana Duch.—Wild Strawberry
Geum canadense Jacq.—White Avens
Geum vernum (Raf.) T.&G.—Spring Avens
Malus coronaria (L.) Mill.—Wild Sweet Crabapple
Malus ioensis (Wood) Britt.—Iowa Crabapple
Prunus americana Marsh.—Wild Plum
Prunus serotina Ehrh.—Wild Black Cherry
Prunus virginiana L.—Common Chokecherry
Rosa setigera Michx.—Climbing Rose
Rubus argutus Link—Tall Blackberry
Rubus occidentalis L.—Black Raspberry

Leguminosae Juss.—Pea Family
Cassia fasciculata Michx.—Partridge-pea
Cercis canadensis L.—Redbud
Desmodium glutinosum (Muhl.) Wood
Desmodium canescens (L.) DC.
Gleditsia triacanthos L.—Honey Locust
Gymnocladus dioica (L.) K.Koch—Kentucky Coffee-tree

Melilotus officinalis (L.) Lam.—Yellow Sweet Clover
Robinia pseudoacacia L.—Common Locust
Trifolium pratense L.—Red Clover
Trifolium repens L.—White Clover

Geraniaceae J.St.Hil.—Geranium Family
Geranium maculatum L.—Wild Geranium

Oxalidaceae Lindl.—Wood-sorrel Family
Oxalis stricta L.—Upright Yellow Wood-sorrel
Oxalis cymosa Small—Common Wood-sorrel

Balsaminaceae Lindl.—Jewel-weed Family
Impatiens biflora Walt.—Spotted Touch-me-not
Impatiens pallida Nutt.—Pale Touch-me-not

Euphorbiaceae J.St.Hil.—Spurge Family
Acalypha rhomboidea Raf.—Three-seeded Mercury.
Chamaesyce maculata (L.) Small—Nodding Spurge

Limnanthaceae Lindl.
Floerkia proserpinacoides Willd.—False Mermaid

Rutaceae Juss.—Rue Family
Zanthoxylum americanum Mill.—Prickly-ash

Anacardiaceae Lindl.—Sumac Family
Rhus radicans L.—Poison-ivy

Celastraceae Lindl.—Staff-tree Family
Celastrus scandens L.—Climbing Bittersweet
Eunonymus atropurpureus Jacq.—Wahoo

Hippocastanaceae T.&G.—Horse-chestnut Family
Aesculus glabra Willd.—Ohio Buck-eye

Staphyleaceae DC.—Bladdernut Family
Staphylea trifolia L.—American Bladdernut

Aceraceae Lindl.—Maple Family
Acer negundo L.—Box-elder
Acer nigrum Michx.f.—Black Maple
Acer saccharum Marsh.—Sugar Maple
Acer saccharinum L.—Silver Maple

Vitaceae Lindl.—Grape Family
Parthenocissus quinquefolia (L.) Planch.—Virginia Creeper
Vitis vulpina L.—Frost Grape

Tiliaceae Juss.—Linden Family
Tilia americana L.—American Linden. Basswood

Malvaceae Neck.—Mallow Family
Abutilon theophrasti Medic.—Butterprint. Velvet-leaf.

Violaceae DC.—Violet Family
Viola eriocarpa Schw.—Common Yellow Violet
Viola papilionacea Pursh.—Butterfly Violet
Viola sororia Willd.—Downy Blue Violet

Araliaceae Vent.—Ginseng Family
Panax quinquefolium L.—Ginseng

Onagraceae Dum.—Evening-primrose Family
Circaea latifolia Hill—Enchanter's Night Shade
Oenothera biennis L.—Common Evening-primrose

Umbelliferae B.Juss.—Parsley Family
Chaerophyllum procumbens (L.) Crantz
Cryptotaenia canadensis (L.) DC.—Honewort
Daucus carota L.—Carrot
Osmorhiza claytoni (Michx.) Clarke
Osmorhiza longistylis (Torr.) DC.
Pastinaca sativa L.—Parsnip
Sanicula canadensis L.—Snakeroot
Zizia aurea (L.) K.Koch—Meadow-parsnip

Cornaceae Link—Dogwood Family
Cornus racemosa Lam.—Gray Dogwood

Primulaceae Vent.—Primrose Family
Samolus parviflorus Raf.—Brookweed
Lysimachia ciliata L.—Fringed Loosestrife

Oleaceae Lindl.—Olive Family
Fraxinus americana L.—White Ash
Fraxinus lanceolata Borkh.—Green Ash
Fraxinus quadrangulata Michx.—Blue Ash

Convolvulaceae Vent.—Morning-glory Family
Cuscuta gronovii Willd.—Dodder
Ipomoea hederacea Jacq.—Ivy-leaved Morning-glory

Asclepiadaceae Lindl.—Milkweed Family
Asclepias syriaca L.—Common Milkweed

Polemoniaceae DC.—Phlox Family
Phlox divaricata L.—Blue Phlox

Hydrophyllaceae Lindl.—Waterleaf Family
Ellisia nyctelea L.
Hydrophyllum appendiculatum Michx.
Hydrophyllum canadense L.
Hydrophyllum virginianum L.

Boraginaceae Lindl.—Borage Family
Lappula virginiana (L.) Greene
Mertensia virginica (L.) Pers.—Bluebells

Verbenaceae J.St.Hil.—Verbena Family
Verbena urticaefolia L.—White Vervain

Labiatae B.Juss.—Mint Family
Agastache nepetoides (L.) Kuntze
Blephilia hirsuta (Pursh) Benth.
Glecoma heterophylla Waldst. & Kit.—Ground-ivy
Leonurus cardiaca L.—Motherwort
Marrubium vulgare L.—Common Horehound
Nepeta cataria L.—Catnip
Prunella vulgaris L.—Selfheal
Scutellaria lateriflora L.—Blue Skullcap
Stachys tenuifolia Willd. — Smooth Hedgenettle.
Teucrium canadense L.—Wood-sage

Solanaceae Pers.—Nightshade Family
Solanum carolinense L.—Horse-nettle
Solanum nigrum L.—Black Nightshade

Scrophulariaceae Lindl.—Figwort Family
Collinsia verna Nutt.—Blue-eyed Mary
Mimulus alatus Ait.—Monkey Flower
Scrophularia marilandica L.—Figwort
Verbascum blattaria L.—Moth Mullein
Verbascum thapsus L.—Common Mullein
Veronica arvensis L.—Corn Speedwell
Veronica peregrina L.—Purslane Speedwell
Veronicastrum virginicum (L.) Farw.—Culver-root

Bignoniaceae Pers.—Trumpet-creeper Family
Campsis radicans (L.) Seem.—Trumpet-creeper

Acanthaceae J.St.Hil.—Acanthus Family
Ruellia strepens L.—Smooth Ruellia

Plantaginaceae Lindl.—Plantain Family
Plantago lanceolata L.—Buckhorn Plantain
Plantago rugelii Dcne.—Common Plantain

Phrymaceae Schauer—Lopseed Family
Phryma leptostachya L.—Lopseed

Rubiaceae B.Juss—Madder Family
Galium aparine L.—Goose-grass
Galium concinnum T.&G.—Shining Bedstraw
Galium obtusum Bigel—Stiff Bedstraw

Caprifoliaceae Vent.—Honeysuckle Family
Sambucus canadensis L.—Common Elder
Viburnum lentago L.—Nannyberry
Viburnum prunifolium L.—Blackhaw

Campanulaceae Juss.—Bellflower Family
Campanula americana L.

Lobeliaceae Dum.—Lobelia Family
Lobelia inflata L.—Indian-tobacco
Lobelia siphilitica L.—Blue Cardinal-flower

Compositae Adans.—Composite Family
Achillea millefolium L.—Yarrow
Actinomeris alternifolia (L.) DC.—Yellow Ironweed
Ambrosia elatior L.—Common Ragweed
Ambrosia trifida L.—Giant Ragweed
Arctium minus (Hill) Bernh.—Common Burdock
Aster pantotrichus Blake—Missouri Aster
Aster pilosus Willd.—Heath Aster
Aster sagittifolius Wedem.—Arrow-leaved Aster
Aster shortii Lindl.—Short's Aster
Bidens vulgata Greene—Common Beggar-ticks
Cacalia muhlenbergii (Sch.—Bip.) Fern—Indian-plantain
Cirsium vulgare (Savi) Airy-Shaw—Bull Thistle
Cirsium arvense (L.) Scop.—Canada Thistle
Erigeron annuus (L.) Pers.—Whitetop
Erigeron canadensis L.—Horseweed
Erigeron philadelphicus L.—Philadelphia Fleabane
Eupatorium purpureum L.—Joe-pye Weed
Eupatorium rugosum Houtt.—White Snakeroot
Helianthus strumosus L.—Sunflower
Helianthus tuberosus L.
Lactuca biennis (Moench) Fern.—Tall Blue Lettuce
Lactuca canadensis L.—Wild Lettuce
Lactuca floridana (L.) Gaertn.
Lactuca scariola L.—Prickly Lettuce
Polymnia canadensis L.—Leafcup
Rudbeckia laciniata L.—Goldenglow
Rudbeckia triloba L.—Brown-eyed Susan
Solidago altissima L.—Tall Goldenrod
Solidago nemoralis Ait.—Field Goldenrod
Solidago rugosa Mill.—Rough-leaved Goldenrod
Solidago latifolia L.—Broad-leaved Goldenrod
Taraxacum officinale Weber—Common Dandelion
Taraxacum laevigatum (Willd.) DC.—Red-seeded Dandelion
Vernonia missurica Raf.—Ironweed

A METHOD FOR CYTOLOGICAL INVESTIGATION OF ALGAE

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The pollen tube technique used for cytological studies of the microgametophyte of Angiosperms was adapted for cytological and morphological studies of algae. This method mainly follows that outlined by Eigsti (1940) for the procedures used in cultivating pollen tubes and the staining and permanent mount technique used in cytological investigations (Eigsti, 1942).

The many hours and many steps necessary in present day methods have stimulated this technique for fast permanent mounts requiring a rather simple procedure. In classes studying morphology and cytology of algae, time would not allow a consideration of personal investigation by the student. It is with two objectives that this report is given. (1) To introduce a new method for detailed cytological investigation of algae on the part of experienced technicians, and (2) to point out to teachers of cytology that this method can easily be introduced as a means of personal investigation by the student.

Vigorous stocks of algae provide the best material. When nuclear phases are desired, examination at various intervals throughout a 24-hour day can be used to acquire proper stages of cells in division.

The desired quantity of the alga should be transferred to a glass slide with a minimum amount of water or fixative. Before the alga has any opportunity to dry out, a thin film of agar imbedding solution is added to the alga mount on the slide. The agar must be liquid at the time of application to the slide and all arrangement of the alga in the agar must be accomplished before the agar solidifies. Only an amount necessary to cover the alga is desired.

The imbedding solution consists of 1 gram of agar and 5 grams of sucrose completely dissolved by boiling in 100 ml of distilled water. The agar mixture is applied to the slide at a temperature of about 40° C. Any agar remaining can be sterilized and kept for subsequent use. A constant temperature water bath for the agar facilitates the operations at the time the mounts are prepared.

As soon as the agar and alga are on the slide, allow the film to dry. Drying is necessary to prevent the film from loosening from the slide as the slide is immersed in reagents used to stain and dehydrate the material. The amount of drying is best judged from experience and is dependent upon the species of alga used. Certain gelatinous forms can withstand drying for several hours. As a general rule, however, the drying process is accomplished within 10 or 15 minutes.

The staining series is made up as follows:

1. *Aceto-carmine*

The aceto-carmine stain is made by reflux condensing for 5 hours at a slow rate one teaspoon of carmine to 100 cc of 45% acetic acid. It is

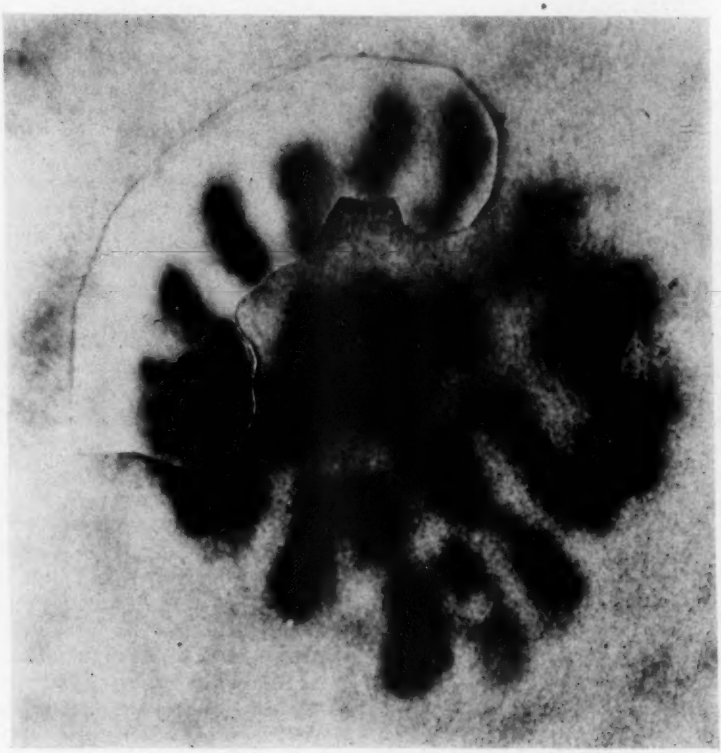

FIG. 1.—Composite photomicrograph of two focal planes of a nuclear division figure of *Rhizoclonium* X8700.

recommended that a minimum time of 20 minutes be given for this stain. The slides may remain in this stain for 24 hours without evident harmful results.

2. *45% Acetic Acid*

This is a destaining solution, and the length of time the slide is in this solution will depend on the length of time the material was in aceto-carmine. If the slide remained in the aceto-carmine for 20 minutes, it is recommended that two minutes in this solution is sufficient.

3. *Glacial Acetic Acid*

This is a destaining agent also, and the length of time the slide is in this acid will depend on the length of time the material was stained. If the slide remained in aceto-carmine 20 minutes and in the 45% acetic acid 2 minutes, one minute in this acid is sufficient. (Note: the amount of staining and destaining will necessarily vary for different types of algae.)

4. *½ Glacial Acetic Acid ½ n Butyl Alcohol*

The slide should remain for 10 minutes in this solution

5. *n Butyl Alcohol*

The slide should remain for 15 minutes in this solution.

6. *Light Green in Clove Oil*

An optional counterstain for making whole mounts of algae.

7. *½ n Butyl Alcohol ½ Xylol*

The slide should remain for a minimum of 10 minutes in this solution. No harmful effects are noted if the slide remains for several hours.

8. *Xylol*

Several changes of xylol are desirable.

The slides may be mounted in balsam for a permanent mount directly from the xylol.

The results from this method have been most gratifying when using plankton forms and many filamentous Chlorophyta. While experimenting with this method, species of *Rhizoclonium* and *Cladophora* were used, as the nuclei are proportionately large. After the method was mastered, the genera of *Spirogyra, Zygnema, Oedogonium, Stigeoclonium* and *Mougeotia* were tried with good results.

In *Cladophora* and *Rhizoclonium* many stages of nuclear division were observed.

In the Myxophyceae excellent results were obtained using *Oscillatoria, Lyngbya, Chroococcus, Merismopedia* and *Gloeotrichia*. Many of the diatoms were processed and excellent results were obtained.

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HOUSTONIA MINIMA IN PEORIA COUNTY

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This paper reports the occurrence of *Houstonia minima* in Peoria County. This species is not listed in the Illinois State Natural History Survey's "Fieldbook of Illinois Wildflowers," published in 1936, and George Neville Jones in his "Flora of Illinois," published in 1945, cites only one instance of a collection in Knox County by Virginius H. Chase of Peoria. Britton and Brown in "Illustrated Flora of Northern United States and Canada," when giving habitat areas, mentions Illinois in parentheses followed by a question mark. The writer considers therefore that any record of its existence in Illinois should be of interest.

The species was found in full bloom, growing in thousands, on April 1, 1945, by Mr. and Mrs. George Schoenbeck, on the Edward Petty farm, located in Hollis township, section 8, on the west branch of LaMarsh Creek. This farm is twelve miles south of Peoria and about four miles west of route 24.

The plants grew in poor soil on a bald bluff overlooking LaMarsh Creek and grew so thick as to make a blue haze over the surface of the ground. The height was only 1 to 1½ inches. The area is a pasture.

The discoverey was immediately reported to Dr. John Voss, Peoria botanist and flower photographer, and director of the Peoria Academy of Science, who made photographs; and to Virginius H. Chase, director of the botany section of Peoria Academy of Science, who was furnished specimens; also to the botany section of the State Academy of Science at the May meeting. This year, 1947, it first started to bloom April 24th, flowers being very scattered among the many plants.

Upon report of the discovery, April 1, 1945, it was learned that the species had been collected in fruit by Chase on May 15, 1933, from a lowland slope one mile east of the Petty farm and east of the older Crescent Mine, a location from which it has long since disappeared, he states.

THE CONTROL OF WEEDS ON A TYPICAL PRAIRIE FARM[1]

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This paper is concerned with the control of weeds on a typical prairie farm in west central Illinois, called "Prairie Farm" in this report.

"A weed is a plant out of place." This definition includes not only the typical forms, but also those that under certain conditions are grown as valuable crops but when found with other crops are detrimental. Any plant able to grow successfully with crop plants may be looked upon as a potential weed.

Perhaps half of our most noxious weeds are those introduced from foreign countries. In Europe, for example, where the soils have been intensively cultivated for centuries, only those weeds that are extremely hardy are able to endure the conditions of cultivation and grow successfully with crops. When seeds of these crops were brought to America where large farms with much waste lands were abundant and cultivation was often less intensive, the foreign weeds accompanying the crop seeds were able to thrive.

Tehon ('37) discusses the reasons why certain weeds in Illinois are classed as pernicious and widespread control measures are needed. He states the conditions under which these weeds do the most damage, the ways in which weeds cause injury, and discusses methods used to control them. However, it is to be noted that none of the thirteen weeds listed by Tehon as the most noxious in Illinois is included in the list of the seven worst weeds on Prairie Farm.

Wilson ('44) has made an analysis of the control of noxious plants. He lists the following characteristics of weeds considered as noxious:

(a) Persistence and vigor of growth.

(b) Poisonous properties of herbage or fruits.

(c) Possession of spines or thorns injurious to animals.

Description of Prairie Farm

The farm chosen for this study consists of 161 acres of gently rolling, rich prairie land situated five miles south of Adair in Eldorado Township in west central Illinois. Most of the soil is brown silt loam with a few small areas of black silt loam. The entire farm is very fertile so that weeds as well as crops grow luxuriantly.

The present owner acquired the farm in 1941 and immediately began laying out the fields as shown in Fig. 1. There are no division fences on the south 80 acres; permanent markers on both the north and south edges divided this part into three equal fields. The other fields are di-

[1] The author wishes to acknowledge his sincere appreciation to H. D. Waggoner for help and encouragement, suggestion of the problem and for guidance in its study; to Roy M. Sallee for making the photographs; to Mary Bennett and R. M. Myers of the biology department of Western Illinois State Teachers College for aid in the preparation of the manuscript. This paper is a condensation of a thesis presented as a partial requirement for the degree of Master of Science which has been deposited in the library of the Western Illinois State Teachers College, Macomb, Illinois.

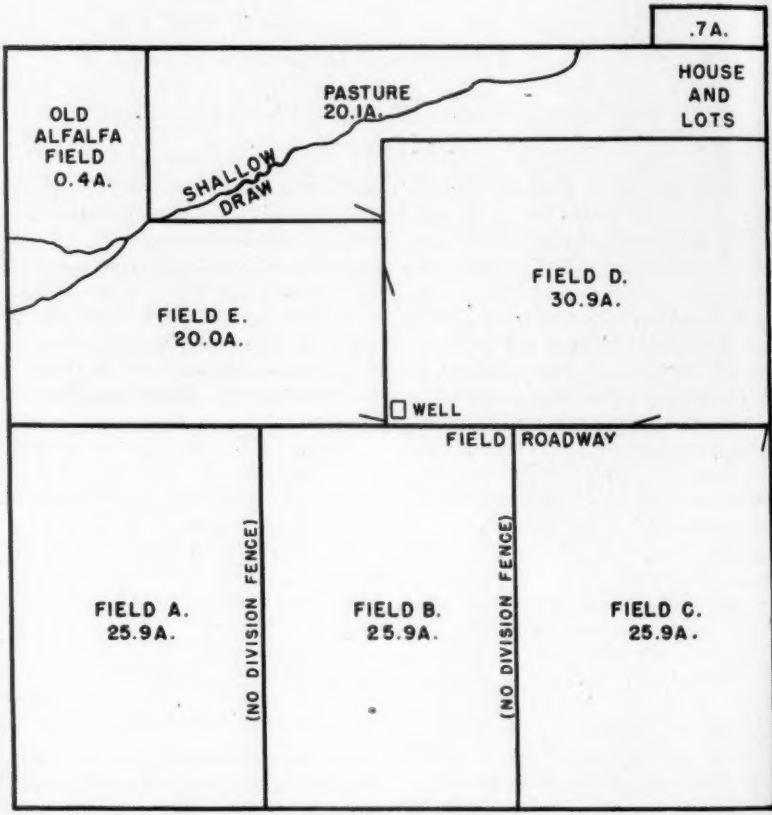

FIG. 1.—Plot plan of Prairie Farm.

vided by permanent fences with gates as shown in Fig. 1. Drainage tile run from all the low places to a ditch which passes through the northwest corner of the farm. There is a flow of water in the ditch during the entire year.

GENERAL METHODS

In order to analyze the program of weed control used on Prairie Farm, approximately 150 weeds on the farm and in the general vicinity were collected, classified, and pressed for a permanent record. Frequent visits were made to the farm during the years 1943 to 1945 for observations. Conferences were held with the tenant and owner concerning procedures and results. Photographs were taken to record significant conditions and changes.

FIG. 2.—A field just across the fence from Prairie Farm. It illustrates conditions in 1941.

CHANGES BROUGHT BY THE CONTROL MEASURES USED

PRAIRIE FARM AS IT APPEARED IN 1941

When the farm was purchased there was no doubt of its fertility, but its productivity was low in everything except weeds, which were everywhere. All fields were badly infested. Weeds were along the fences, in the rows and in between the crop rows. Figure 2 illustrates the condition of some of the fields.

The seven most noxious weeds are listed in table 1.

Immediately upon acquiring the farm, the new owner began a definite system of crop rotation. This usually consisted of corn; soy beans; oats and clover. Modifications were made if clover or other crops failed. An intensive program of weed eradication and control was also started.

At all times much attention was given to clean farming. Weeds were destroyed before seeds could mature; in the corn fields with a hoe, in soy beans by pulling, and in clover and oats by cutting at harvest time.

The seven most noxious weeds (table 1) can be divided into two groups: group "A" consists of milk weed, Indian hemp and hedge bindweed. This group is difficult to control because they grow from under-

TABLE 1.—THE SEVEN MOST NOXIOUS WEEDS ON PRAIRIE FARM

Scientific Name	Common Name
**Abutilon theophrasti Medic*	Velvet Leaf
**Amaranthus retroflexus L.*	Rough Pigweed
Apocynum cannabinum L.	Indian Hemp
Asclepias syrica L.	Common Milkweed
Convolvulus sepium L.	Hedge Bindweed
**Echinochloa crusgalli (L.)* Beauv.	Barnyard Grass
Polygonum pennsylvanicum L.	Pennsylvania Smartweed

All plants were classified according to Gray ('08).
*Indicates that weed is of foreign origin.

FIG. 3.—Field of soy beans in 1945. Not a weed could be found in this field.

ground parts in which considerable food is stored. Group "B" includes the remaining weeds; pigweed, Pennsylvania smartweed, velvet leaf, and barnyard grass. These weeds reproduce by seeds. It was easier to eradicate the weeds in group "B" than those in group "A", but it was more difficult to keep them under control.

The most effective method found for eradication of milkweed and Indian hemp was by pulling the plants and breaking off the stem several inches below the surface of the soil, thus preventing food storage required to promote growth the next year. The hedge bindweed was cut with a hoe for the same reason. In group "B" the weeds were cut in the blossom stage or a little later, thus preventing the maturing of seeds. This cutting had to be repeated several times each year. In addition there was careful preparation of the seed bed and cultivation of the various crops as required.

AFTER FOUR YEARS

In 1945 as a result of the program of eradication and cultivation there were few weeds on Prairie Farm, especially those having underground food storage regions. The milkweed had almost entirely disappeared. It was estimated that there was a decrease of more than 90 percent in the numbers of Indian hemp and hedge bindweed. In a field of rowed soy beans it was almost impossible to find a weed (fig. 3.) Weeds were also much reduced in the corn fields. It required considerable search to locate any hedge bindweed. In 1941 it would have been difficult to find a single corn stalk without bindweed.

It must be noted that it was necessary to continue the weed control measures. In 1945 the tenant failed to cultivate a corn field across the rows and cultivated only twice in the rows during the growing season. The result was a considerable growth of weeds in the rows of corn. These weeds probably came from seeds in the soil, as it has been shown that

weed seeds may survive for many years.

Conclusions

1. It is possible in a period of five years to eradicate or control many of the noxious weeds of a typical prairie farm in west central Illinois.

2. Control can be accomplished only by carefully planned, intensive work.

3. To maintain control of the weeds it is necessary to continue a planned type of crop rotation and cultivation because one year of poor cultivation may undo the work of several years.

4. If cultivation is to result in the destruction of weeds, it should begin sufficiently early in their development to prevent their becoming well established.

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VIRGINIUS H. CHASE

VIRGINIUS H. CHASE, PEORIA BOTANIST

HARRY L. SPOONER
Peoria Academy of Science, Peoria

VIRGINIUS HEBER CHASE was born January 8, 1876, at Wady Petra, Stark County, Illinois, the son of Heber and Emma Brain Chase.

He is of the eighth generation from Aquila Chase, a sailing master honored by a stone tablet in the New England Historic Genealogical Building in Boston, Massachusetts, as being the first pilot at the mouth of the Merrimac River.

Aquila Chase took up land in Hampton, New Hampshire in 1640. In studying the family tree, the only record of a member being arrested for a misdemeanor is that of Aquila himself, his wife, and her brother "for gathering pease on the first day of the week." Since this all took place in a Puritan village back in 1646, perhaps the family may be said to have outlived the disgrace.

Many in the Chase line have left honorable records. For instance, the children of Deacon Dudley Chase, who represented the fifth generation from Aquila, include a physician; a successful lawyer; a bank president; a judge of the Supreme Court of Vermont, United States Senator and a member of the Council of New Hampshire, who was the father of Lincoln's Secretary of the Treasury, Chief Justice Salmon P. Chase; and of Philander Chase, the first Episcopal Bishop of Ohio and founder of Kenyon College and later the first Bishop of Illinois and founder of Jubilee College.

While we refer to Virginius Chase as a botanist, he does not aspire to that title, but would rather be considered as of the old school of naturalists, getting his joy of life from reading the book of Nature and sharing it with his friends, as did Gilbert White of Selborne and Henry D. Thoreau of Walden, and if he has a motto, it probably is that of Thomas Paine, "The world is my country and to do good is my mission."

He would not deny it if you accused him of being a collector of the most incurable type—in fact, he would prove it to you.

His first lesson in botany came at the age of three, when he toddled out to the garden and tried to eat a pretty red pepper. Perhaps Mr. Chase is not a scientist, for scientists say nothing is ever proved by a single experiment and Chase did not repeat this one. To this day, the odor and flavor of peppers of any kind are still repulsive to him.

We find the old saying, "as the twig is bent, the tree's inclined," well exemplified in Mr. Chase's case. As a child at his grandmother's home, he was allowed to look at a large prehistoric stone axe that his grandfather had found and to handle a large pink arrowhead. Then there was a woven covered basket that a sailor, a great uncle, had brought back on his last voyage from Calcutta, India, which was filled with shells from tropic seas.

A few years later, the inspection of the collection of birds' eggs of Ernest Chamberlain at Robin's Nest

Farm, proved a greater attraction than the whole World's Fair did in 1893.

At the age of five, a few days of frantic effort covered the bottom of a cardboard box with pinned butterflies, grasshoppers and beetles. A few weeks later, pests well known to all entomologists had reduced the collection to dust and that was the end of that.

Permission to collect birds' eggs was not received until some years later, in district school days. To this day, he will tell you the greatest thrill of his whole life was when he climbed the old cottonwood tree in the south pasture and saw and collected his first set of crow's eggs.

His days in district No. 9 school are chiefly remembered by the noon trips to the forty or more acres of original prairie sod a half mile to the east, with its undulating surface, where *Cypripedium candidum* grew by hundreds, *Dodecatheon meadia* by millions and *Phlox maculata* by the acre. Across the road from this were five acres which were almost a solid growth of *Iris*. Birds' eggs were the objects of the trips, but in case he might be tardy when the one o'clock bell rang, a large bouquet or an armload of the choicest flowers were always taken back to keep the teacher in good humor, and somehow he says it always worked.

Eggs of redwing blackbirds in the *Iris* and of meadowlarks and Bob Whites in the grass were abundant. The finding of the eggs of the upland plover was a rare thrill and to find those of the kildeer a constant dare. To find the eggs of the migratory shrike was a rare treat and after being away twenty years, he was much

VIRGINIUS H. CHASE
19 years of age

pleased to find a pair, probably descendants of those he had robbed years ago, were again nesting in the same clump of trees.

In going home from school, a slight detour gave a quarter of a mile of dense bottomland thicket to explore, where he found nesting black-crowned night herons and little green herons, yellow-breasted chats and the commoner species. It was mostly a thicket of *Prunus americana* and *Malus ioensis*, roofed over with *Vitis riparia*. In the openings, *Trillium recurvatum* and *Mertensia* were the most abundant of flowers.

After district school days, two winters at Princeville academy ended all formal education. Then a few weeks' instruction in tele-

graphy at Wyoming and Chase took charge of the telegraph office and railroad station at Wady Petra.

With short hours and much leisure, the boy was ready for new worlds to conquer, for the commoner birds' eggs were already in his collection and others seemed to have been beyond walking distance.

At the World's Fair of 1893, he first saw a herbarium specimen and that settled it—a herbarium was the thing he wanted and must have.

His mother's old Gray's Manual she had used at Kansas University when she studied under the famous Dr. Snow looked intriguing but seemed beyond his comprehension, and his mother appeared to have forgotten the little learned in the few weeks of school. His aunt, Agnes Chase, at that time knew no botany, but with mutual interest they tackled the problem together. The night Agnes succeeded in running down *Campanula americana* by herself, the game was on for them both, and for that matter, still is.

For the first few years, Agnes in Chicago, a proof reader on the Chicago Inter Ocean, and Virginius at Wady Petra, in the railroad station, collected at every opportunity, and by exchange of fresh material by mail, verified each other's determinations.

Mr. Chase's correspondence with Hill, Ruth, Porter, Wooten, Brainerd, Lunell, Sargent, Henderson, Wheeler, Bicknell, Beal and others, and exchanges of specimens with National Herbarium, Gray Herbarium, Missouri Botanical Garden, Gleason at the University of Illinois and others made life worth while.

Chase collected plants of *Viola* for Brainerd's garden experiments, and grafts, fresh flowers and hundreds of herbarium specimens of *Crataegus* for Sargent to use in his historic round-up of that genus. Prof. Sargent came to Wady Petra to personally see the type trees of his new species—*Crataegus peoriensis* and *Crataegus pratensis*—growing, and also trees of *Crataegus illinoensis*, which Ashe had recently described from material collected by Chase.

Opinions differ, but Chase still thinks Sargent, with his field studies, knew more about *Crataegus* than any who have come since.

An incident Chase will always remember was when he put in a good part of two days trying to run down a plant with distinctly parallel-veined leaves, as all good monocotyledonous plants are supposed to have, even to reading over the description of every species in that group, only to have to give up in despair. Months later by accident he stumbled on the name of *yuccifolium* and found his plant was an *Eryngium* placed among the *Umbelliferrae*—a booby trap others no doubt have fallen into even though they don't confess.

Mr. Chase and Frank E. McDonald, another Peoria botanist, were good friends, and after selling his herbarium to the University of Illinois, McDonald gave Chase his large herbarium case and his book of notes and plant records. After McDonald's death, Chase bought his botanical library and later Mrs. McDonald gave him the moss herbarium of 2000 specimens McDonald had made during the last years of his life.

After turning over the telegraph office to a younger brother, Chase

built a grain elevator and conducted a successful business in lumber, drain tile, coal and feed at Wady Petra for five years. Then, the rest of the family having moved to Kansas, Chase traded his interests in Wady Petra for Kansas land and in three years found himself penniless and in debt.

Then followed a year with a produce dealer and wholesale grocer at Paragould, Arkansas, then a few months with an Illinois well driller, and five years in Peoria grocery stores working ten hours a day and sixteen on Saturday.

The next 28 years were spent in the P. & P. U. railroad freight house at Peoria with practically no vacations, and during two world wars working seven days a week and nine to ten hours a day, so one may perhaps be able to forgive him if he did not get much done. He did act as president of the local Audubon Society, Boy Scout Committeeman, Boy Scout Commissioner and Examiner in Bird Study and Botany for the Boy Scouts.

In addition to his collecting in Illinois, may be mentioned some 150 species in Butler county, Kansas and 664 numbers collected in a hurried trip of only 24 days with Dr. C. D. Sneller via Bad Lands of South Dakota, Black Hills, and Yellowstone National Park to Craters of the Moon and back by way of Montana and Minnesota.

A set of the plants collected at the Craters of the Moon was mounted, labeled and presented to the superintendent of the monument as the nucleus of a herbarium to show those species growing within its boundary. Two hundred fifty specimens from this trip went to the National Herbarium and a full set to the Peoria Academy of Science.

In 1939 Mr. Chase went as botanical collector to Mexico with the second Hoogstraal scientific expedition from the University of Illinois. In spite of a wreck, which deprived the expedition of its leader and forced it to travel with no windshield and only a tarpaulin to protect the specimens, Chase managed to bring back ten sets of herbarium specimens. The first set was given to the Field Museum for identification, and Dr. Standley declared it to be the best prepared lot he had ever seen come out of Mexico. Another set was given to the Peoria Academy of Science. A set of 160 grasses was presented to the National Herbarium.

To help defray expenses of the expedition, sets were sold to Gray Herbarium, University of Michigan, Missouri Botanical Garden, Carnegie Desert Museum, U. S. Division of Plant Industry, New York Botanical Garden, and University of Illinois—in all, approximately 5000 sheets.

The finding of *Syringantha loranthoides*, a tall shrub, collected only once before since it was originally collected nearly a hundred years before; collecting *Bouteloua heterostega*, which had never before been collected on continental America, and *Paspalum malacophyllum*, which had been collected in North America but once, in Yucatan; and collecting *Muhlenbergia thurberi* for the first time in Neuvo Leon, as well as two unnamed species, was quite gratifying as that particular region

had been considered pretty well worked before.

In an old publication, "Birds," issued by Nature Study Publishing Co., Chicago, one of the first publications to use crude color photography, one may find pictured the nests of orchard oriole and rose-breasted grosbeak made from nests collected by Chase and sent to the Chicago Academy of Science while Frank Baker was curator and Woodruff, taxidermist.

Mr. Chase's first published item, "A Battle of Ants," appeared in Popular Science of December, 1897. A brief sketch of the life of Frank E. McDonald was published in Rhodora of September, 1920. Between 1923 and 1926 twenty issues of the Peoria Star contained timely column articles on nature study of local interest.

For the program of the meeting of the Illinois State Academy of Science in Peoria in 1931 he presented a sketch of the life of Dr. Frederick Brendel. Two years later, when the Peoria Academy of Science organized sections for special studies, he was placed at the head of the section on Botany and Dr. C. D. Sneller, then president, said, "Of course Chase must be custodian—he has it as an enzyme in his blood," and he has held the two appointments ever since. He also served as president of the Peoria Academy in 1937.

As publicity for the Academy, under the heading of "Nature Rambles," the Peoria Star published each Sunday between 1933 and 1936 a total of 130 articles on many lines of nature study by Chase.

Two years ago, Mr. Chase donated to the University of Illinois all duplicate herbarium specimens on hand, some 8000 sheets.

His private herbarium contains 18,240 sheets of ferns and spermatophytes of the United States, 1061 sheets of foreign plants, and 2107 packets of mosses and hepatics, a total of 21,408 specimens. Besides these, he has prepared and mounted 6571 sheets for the Peoria Academy collection.

His special interest at the present time is a seed collection put up in two-dram vials—now only in the second hundred.

His private collection of shells—marine, land, and fresh water, exceeds 200 species. Of fossils from coal vein No. 2 of the famous Mazon region he has representatives of a good portion of the known species and also a fair collection from local stripping of coal No. 5 and coal No. 6 in marine fossils.

His personally collected Indian artifacts number more than 2000.

Of new species of plants to his credit he has:

Psaronius peoriensis and *Psaronius septentrionalis,* two species of fossil fern bark of Peoria county, presumably of Permian age, described by Gillette in Botanical Gazette, Vol. 49, Sep. 1937;

Xanthium chasei, a new cockle bur from Tazewell county, Illinois, described by M. L. Fernald in Rhodora, Vol. 48, April, 1946;

Galium juniperinum, a bedstraw from Neuvo Leon, Mexico, described by P. C. Standley in Botanical Series, Field Museum of Natural History, Vol. 22, June 12, 1940;

Bouteloua chasei, a grass from Neuvo Leon, Mexico, described by

Jason Swallen in Proceedings of the Biological Society of Washington, Vol. 56, page 81, Sep. 10, 1943;

Crataegus illinoensis, a red haw from Stark County, Illinois described by W. W. Ashe in Journal of Elisha Mitchell Scientific Society, Vol. XVI, Feb. 1900;

Crataegus peoriensis, a red haw from Stark and Peoria counties, Illinois, described by C. S. Sargent in Botanical Gazette, Vol. XXXI, January, 1901;

Crataegus pratensis, another species of red haw from the same region, described by Sargent in the same issue as the preceding.

From living and herbarium material collected by Mr. Chase, two hybrid violets, *Viola pēdatifída* x *sagittáta* and *Viola pēdatifída x sororia* were described by Ezra Brainerd in Bull. Torr. Bot. Club, Vol. 40, June, 1913.

In publishing *Panicum praecocius,* Hitchcock and Chase, in Rhodora, Vol. 8, 1906, took V. H. Chase's number 649, collected at Wady Petra, Illinois, as the type specimen.

That Mr. Chase has many loyal friends is attested by the fact that at Bradley University, Peoria, will be found the name of Virginius H. Chase on the Roll of Distinction, placed "in recognition of his contributions to the study of Systematic Botany, especially with reference to the Flora of Illinois." He has also been elected a life member of the Peoria Academy of Science.

Now, having recently retired, he says at last he hopes to get started doing something!

THE ACANTHACEAE OF ILLINOIS

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This study deals with the genera and species of the Acanthaceae[1] known to occur in Illinois. It is intended to present an account of the members of this family, with a means of their identification. Attention has been given to the study of *Ruellia*, with special regard to the status of *Ruellia humilis* Nutt. and *R. ciliosa* Pursh. The data for the study of geographical distribution, and taxonomic characters of genera and species have been taken from specimens in the herbarium of the University of Illinois and that of the Illinois State Natural History Survey.

The writer wishes to express gratitude for the privilege of using facilities of the Natural History Library of the University of Illinois. Generous assistance furnished by Dr. G. N. Jones of the botany department as to bibliographical material, suggestions for style of arrangement, and taxonomic concepts involved has been valuable. Thanks are due L. R. Tehon and R. A. Evers of the Natural History Survey for making available many of the herbarium specimens used in this study.

Keys are provided for the identification of the genera and the species. The statements of geographical range have been based upon P.A. Rydberg's *Flora of the Prairies and Plains of Central North America*, (1932).

[1] Acanthaceae, a family of 175 genera and about 2000 species.

Key to the Illinois Genera

1. Corolla two-lipped, fertile stamens 2; plants growing in water or along muddy shores; leaves entire, lanceolate .....Dianthera
1. Corolla nearly regular, fertile stamens 4; plants of drier habitat; leaves broader .....Ruellia

Dianthera americana L. Sp. Pl. 27 (1753).

Lapham (1857) 526; Patterson (1874) 11, (1876) 28; Brendel (1887) 86; Huett (1897) 112; Pepoon (1927) 471; McDougall (1936) 315; Fuller (1943) 98; Jones (1945) 233.

Justicia americana (L.) Vahl, Symb. Bot. 2: 15 (1791).

Type locality: "Habitat in Virginia."

Range: Common along muddy shores of streams, and margins of shallow ponds and lakes from Quebec to Wisconsin and south to Kansas, Texas, and Georgia. Flowering from July to September.

Adams County: Burton Creek near the cave, 4 June 1943, R. A. Evers 1138. Waters of Camp Creek, 29 May 1932, Pepoon & Barrett 2241.

Champaign County: Wet bank along Salt Fork near Sidney, 3 October 1940, G. N. Jones 13216; 20 July 1940, G. N. Jones 12460. Urbana, 7 July 1886, Waite. In ditch, St. Joseph, 24 July 1928, McDougall 152. Sandy bottom, shallow water Middle Fork of Vermilion River, 18 October 1928, Tehon & Thompson 2246.

Coles County: Paradise Lake, in water two feet deep, 8 June 1929, D. H. Thompson 2244.

Cook County: Palos Park, 6 June 1906, H. C. Cowles.

Fayette County: Dismal Creek, northeast of Farina, 14 July 1940, Louise O'Dell 375.

Grundy County: Mazon Creek, 12 June 1932, Pepoon & Barrett 5183.

Hardin County: River strand plant on limestone boulder in Ohio River near Elizabethtown, 24 June 1931, J. Schopf 2243.

Henderson County: Oquawka, H. N. Patterson.

Jefferson County: Margin of pond, 1 June 1932, Pepoon & Barrett 5233.

Kankakee County: Kankakee River northwest of Kankakee, 3 August 1912, Sherff 1603. Sandy flats along Kankakee River, 19 June 1937, R. A. Schneider 2250.

LaSalle County: Little Vermilion River at Troy Grove, 8 September 1931, Pepoon & Foster 970.

Livingston County: Pontiac, 25 July 1944, G. D. Fuller 9146.

Macon County: Lake Decatur, upper end, 26 July 1929, W. Luce.

Macoupin County: Carlinville, 2 July 1890, W. E. Andrews. Gravelly and sandy soil near Carlinville, 13 July 1940, G. D. Fuller 2248. Carlinville, 23 August 1882, C. Robertson 2252.

Pope County: In Big Grand Pierre Creek northeast of Golconda, 19 July 1941, G. H. Boewe. Two miles east of Herod, 7 July 1931, J. Schopf 2242.

Union County. Mill Creek, 1 June 1932, Pepoon & Barrett 4520

Vermilion County: Seymour & Butts, 24 June 1880.

Wabash County: Wabash River at Mt. Carmel, 8 June 1894, J. Schneck. Sandy shore, Wabash River, 10 June 1932, Pepoon & Barrett 5139.

Wayne County: Shallow water, 13 June 1944, G. D. Fuller 8709.

Williamson County: Grassy Creek at Devil's Kitchen, 2 June 1941, McCree 806.

Key to the Illinois Species of Ruellia

1. Stem simple to slightly branched, leaves lanceolate, oblong to ovate.
   2. Calyx segments lanceolate, 2-4 mm. broad, capsule glabrous.... .....*R. strepens*
   2. Calyx segments 0.5-1 mm. wide, tapering to the tip, capsule pilose; flowers on slender peduncles .....*R. pedunculata*
1. Stem decumbent with bushy habit, leaves narrow, oblong, lanceolate, the tips blunt or rounded, coarsely villous; calyx 1.5-2.5 cm. long; capsule glabrous. .....*R. humilis*

Because of variations among some of the specimens of *R. humilis* Nutt., naming of intergrading varieties and forms has been omitted from the present treatment of Illinois species of this genus. Neglect of original descriptions may be a basic reason for the fact that much confusion seems to have existed for a century over the correct identification of *R. humilis* Nutt. and *R. ciliosa* Pursh. Many careful and reliable taxonomists have failed to note the obvious differences between *R. ciliosa*, as we have ordinarily identified it, and the original description by Pursh. As pointed out by Fernald (1945), the name *R. ciliosa* Pursh should be retained for a plant of the southeastern states and the Gulf Coast regions.

Ruellia strepens L. Sp. Pl. 634 (1753); Schneck (1876) 546; Patterson (1876) 29; Brendel (1887) 55; Gates (1926) 230; Pepoon (1927) 471; McDougall & Liebtag (1928) 231; Stover (1930) 25; McDougall (1936) 316; Jones (1942) 72; Fuller (1943) 98; Fernald (1945) 16; Jones (1945) 234.

Dipteracanthus strepens (L.) Nees in Linnaea 16: 292 (1842); Lapham (1857) 526; Forbes (1870) 318.

Hygrophila illinoiensis Wood ex. A. Gray, Syn. Fl. N. Am. 2[1]: 327 (1878), erroneously assigned to Bull. Torr. Club 5: 41 (1874).

Ruellia strepens var. *cleistantha* A. Gray, Syn. Fl. N. Am. 1: 327 (1878).

Ruellia strepens f. *cleistantha* (A. Gray) S. McCoy in Am. Bot. 43: 24 (1937).

Type locality: "Habitat in Virginia, Carolina."

Range: Common in alluvial soil throughout Illinois, and from Pennsylvania to Iowa and south to Texas and Florida; flowering in Illinois from June to August.

Scott McCoy's paper (Am. Bot. 43: 24, 1937) gives an interesting account of observations from a specimen of *Ruellia strepens* transplanted to his garden. In June the plant bore flowers typical of the species and in autumn produced cleistogamous flowers.

Three specimens examined by the writer revealed that those collected from mid-August to November bore capsules closely packed in the axils of the upper leaves.

Adams County: Moist alluvial soil, eight miles south of Quincy, 8 September 1943, G. D. Fuller 3005.

Calhoun County: Along roadway through timber, Pere Marquette Study

Area, 11 October 1939, G. H. Boewe. Steep talus below Kampsville, 30 May 1933, Pepoon & Barrett 4399.

Champaign County: Sangamon River 15 miles west of Urbana, 21 June 1942, N. R. Piesbergen. University Woods near Urbana, 18 October 1941, G. N. Jones 15008. Roadside, Urbana, 6 July 1928, W. B. McDougall 52. Woods, Urbana, 17 June 1880, Seymour & Butts. Thicket, "St. Joe to Sidney," 16 September 1889, G. P. Clinton. Woods along Salt Fork River, near Urbana, 3 October 1943, G. N. Jones 16316. Near Urbana, 19 June 1941, G. N. Jones 13909. Grassy roadside, near Urbana, 28 June 1940, G. N. Jones 11818. Sangamon River bottoms near Mahomet, 29 September 1940, G. N. Jones 13120.

Fulton County: Sandy ground, Liverpool, 6 August 1891, H. S. Pepoon.

Hancock County. Crooked Creek bottom, 10 September 1916, F. C. Gates.

Kankakee County: Rich soil, 2 June 1872, E. J. Hill.

Livingston County: Moist woods, five miles south of Pontiac, 26 July 1944, G. D. Fuller 9196.

Macoupin County: Carlinville, 19 June 1882, C. Robertson 2277. Carlinville, 19 August 1889, W. E. Andrews. Carlinville, 19 June 1889, W. E. Andrews.

Macon County: Decatur, May 1896, I. W. Clokey. Three miles east of Decatur, cleared hill top, 30 May 1915, I. W. Clokey 2486.

Menard County: Moist ravine, New Salem, 10 September 1940, G. D. Fuller 3015.

Peoria County: Peoria, dry open woods, July 1892, F. E. McDonald. Rich woods, Peoria, July 1901, F. E. McDonald. Low grounds, Peoria, July 1887, F. E. McDonald. (Without number or date) Peoria, F. Brendel as *Dipteracanthus strepens.*

Pike County: East Hannibal, 3 June 1913, J. Davis 4623.

Pulaski County: Swampy ground one mile north of Ullin, 5 June 1941, G. H. Boewe.

Richland County: Near Olney. "Birdhaven," 8 October 1920, R. Ridgway 1320.

Sangamon County: Rich soil, Salisbury Township, 18 August 1941, G. D. Fuller 6537.

St. Clair County: Mascoutah (without number or date) W. Welch as *Dipteracanthus strepens.*

Union County: Rich soil, woods, 25 September 1940, G. D. Fuller 334.

Wabash County: In cut-over wooded area about one mile north of Bellmont, 29 May 1941, G. H. Boewe. Crawfish Bridge, 4 July 1893, J. Schneck. Gleck's field, 8 June 1878, J. Schneck. Mt. Carmel; a specimen in which the "flower is a deeper red and has a smaller flower, especially in the expanded portion, than the regular form." July 1880, J. Schneck.

Ruellia pedunculata Torr. ex. A. Gray, Syn. Fl. N. Am. 2[1]: 325 (1878). Britton and Brown (1913) 3: 242; McDougall (1936) 316; Fuller (1943) 98; Jones (1945) 234.

Type locality: "Dry woods in W. Louisiana, J. Hale. Arkansas, Bigelow, Mrs. Harris."

Range: In dry, open woods in southern Illinois to Oklahoma, eastern Texas and Louisiana. Flowering from June to August and commonly called the Stalked Ruellia.

Alexander County: Rich woods two and one-half miles south of Diswood, 27 September 1931, Pepoon & Barrett 695.

Johnson County: Dry soil, Tunnel Hill, 26 May 1902, J. Schneck.

Pulaski County: In open woods on top of dry hill one and one-half miles northwest of Ullin, 18 June 1941, G. H. Boewe.

Saline County: On a rocky slope of Swartz Hill in northeast Saline County, 12 September 1931, Pepoon & Foster 1405.

Union County: Anna, 13 August 1880, A. B. Seymour. In the shady wood edge, along roads, 13 June 1927, G. L. Stout 2271. In open woods one mile northeast of the city limit of Anna, 29 August 1931, J. Schopf 1557. Open woods back of peach orchard, one mile northeast of city limit of Anna, 29 August 1931, J. Schopf 1544.

Ruellia humilis Nutt. in Trans. Am. Phil. Soc. 5: 182 (1837).

Dipteracanthus ciliosus (Pursh) Nees in Linnaea 16: 294 (1842); Lapham (1857) 526; Forbes (1870) 318.

Dipteracanthus noctiflorus β humilis (Nutt.) Nees in DC. Prodr. 11: 123 (1847).

R. ciliosa, var. *longiflora* A. Gray, Syn. Fl. 2: 236 (1878).

R. ciliosa var. *humilis* (Nutt.) Britt. in Trans. N. Y. Acad. Sci. 9: 185 (1890).

R. ciliosa sensu Mead (1846) 119; Babcock (1872) 146; Patterson (1874) 11; Hyatt (1875) 67; Patterson (1876) 28; Schneck (1876) 546; Brendel (1887) 55; Higley & Raddin (1891) 90; Huett (1897) 112; Snare & Hicks (1898) 16; Gleason (1907) 187; Gleason (1910) 166; Thone (1935) 105; Pepoon (1927) 471;

McDougall (1936) 316; Jones (1945) 234.—Not *R. ciliosa* Pursh (1814).

R. caroliniensis sensu Fuller (1943) 98. Non (Walt) Steud.

R. humilis var. *typica*, Fern. in Rhodora 47; 54 (1945).

R. humilis forma *grisea*, Fern. in l. c. 54.

R. humilis var. *frondosa*, Fern. in l. c. 54.

R. humilis var. *longiflora* (A. Gray). Fern. in l. c. 56.

R. humilis var. *expansa*, Fern. in l. c. 58.

Type locality: "Hab. On rocks in the upland forests and prairies." (Type or isotype, an Arkansas specimen from Nuttall in the Torrey Herbarium).

Range: In dry soil, along roads, on grassy banks, and dry slopes from southern Michigan to southeastern Nebraska, Iowa, and Missouri, and southward to eastern Texas, Louisiana, and northwestern Florida. Flowering in Illinois from June to September.

In this study the following characters have been used in order to separate the intergrading varieties and forms of this species: leaf shape, length of internode, kind and degree of pubescence, length and shape of sepals, and length of corolla. According to Nuttall's description of *R. humilis*, the plants are erect, hirsute, the leaves oblong-ovate, sessile, the peduncles 1-3-flowered, and the tube of the corolla twice the length of the laciniate, filiform calyx lobes. The leaves were indicated as "very similar to those of *R. strepens*, but sessile and not perfectly entire." The flowers were said to be pale blue and commonly two inches long. *Ruellia humilis* forma *grisea* Fern., with a more extreme pubescence than *R. humilis* var. *typica*, is scattered through the range of the latter. In *R. humilis* var. *longiflora* (A. Gray) Fern. the corolla is indicated as five to eight centimeters long, the veins and the margins of the leaves copiously villous-hirsute. *R. humilis* var. *expansa* Fern. has leaves described as ovate to ovate-oblong. They vary somewhat in size but agree in degree of pubescence.

Cass County: Sandy soil at edge of timber, five and one-half miles south of Beardstown, 27 June 1941, G. H. Boewe.

Champaign County: Urbana, 15 July 1878, A. B. Seymour. Urbana, 13 July 1880, A. B. Seymour. Urbana, 25 June 1897, G. P. Clinton. Grassy bank near Urbana, 1 August 1940, G. N. Jones 12686. Near Urbana, 20 July 1940, G. N. Jones 12531. Near Urbana, 10 September 1939, G. N. Jones 10714. Near Urbana, 24 June 1942, N. R. Piesbergen. Grassy bank near Urbana, 1 July 1940, G. N. Jones 12250. One mile east of Mayview, 18 June 1942, G. H. Boewe. One-half mile northeast of Rantoul, 1 July 1942, G. H. Boewe.

Christian County: One and one-half miles northeast of Stonington, 24 June 1942, G. H. Boewe.

Cook County: Calumet, dry hills (without name), 12 July 1865. Sandy soil, Custer Park (without date), W. S. Moffatt 570. Dry rocky places, Lemont, 29 June 1898, A. Chase 877. Dry rocky ground, Lemont, 29 June 1898, E. J. Hill.

Cumberland County: Hazel Dell Area, July 1939, C. S. Spooner.

Douglas County: Arcola, 2 July 1939, C. Mohr.

Hancock County: Prairie along Wabash R. R., 11 September 1916, F. C. Gates.

Henderson County: Sandy, open places, 27 May 1932, Pepoon & Barrett.

Jasper County: East of Wheeler, 9 June 1941, G. H. Boewe.

Jefferson County: Southeast of Centralia, 25 July 1930, L. Campbell & C. Alexopoulos.

Kankakee County: Three miles northwest of Bonfield, 18 July 1943, G. N. Jones 15942. Sandy swales, 11 June 1932, H. S. Pepoon 2258.

Macon County: Stevens Creek at Wabash, openings in timber, 1 July 1915, I. W. Clokey 2429.

Macoupin County: Carlinville, 21 June 1889, W. E. Andrews. Carlinville, moist soil in partial shade, 13 July 1940, G. D. Fuller 2249.

Mason County: Havana, 13 June 1894, T. J. Burrill. Havana, 27 June 1910, F. C. Gates 3471. 25 June 1942, G. H. Boewe. Havana, low, sandy forest, 12 July 1940, G. D. Fuller 2231.

Morgan County: Near Manchester, 30 May 1932, Pepoon & Barrett.

Ogle County: Oregon, "Liberty Hill," dry soil, 7 August 1883, M. Waite. Byron, dry hillsides, 17 August 1895, W. S. Moffatt 455. Oregon, rocky banks, 18 August 1895, W. S. Moffatt 455. Open woods White Pines State Park, 8 July 1942, G. D. Fuller 3435-0.

Peoria County: Peoria, dry prairies, July (date incomplete) F. E. McDonald.

Pike County: Along a steep wooded creek bank, 1 July 1943, G. H. Boewe. Roadside east of El Dara, 22 June 1931, L. R. Tehon.

Pope County: Rocky dry wooded hillside northeast of Golconda, 19 June 1941,

G. H. Boewe. Growing in oak-elm woods, 3 July 1931, J. Schopf 348.

Shelby County: Roadside two miles east of Windsor, 25 June 1940, G. H. Boewe. Two miles east of Tower Hill, 24 June 1941, G. H. Boewe.

Stark County: Gravel slope near Wady Petra, 9 July 1900, V. H. Chase 673.

Tazewell County: Sunny, sandy banks south of Pekin, 17 July 1932, Pepoon & Barrett.

Union County: Cobden, 25 July 1886, F. S. Earle. Pine Hill, rocky, shaded hillside, 11 September 1940, G. D. Fuller 266.

Vermilion County: Along Vermilion River between Oakwood and Collison, 23 June 1940, G. N. Jones 11620.

Wabash County: Dry, hard soil, 20 June 1902, J. Schneck.

Winnebago County: Above Rockford, 23 June 1933, H. S. Pepoon.

Summary

A study has been made of the genera and species of Acanthaceae occurring in Illinois, and keys have been provided for their identification. A county distribution of the species is included.

Only one species of Dianthera, *D. americana*, is known to occur in Illinois. *Justicia humilis* Michx. Fl. Bor. Am. 1: 8 (1803), was reported from southern Illinois by E. J. Palmer (1921) 134 as *Dianthera ovata* Walt. However, there appear to be no Illinois specimens in the herbarium of the Missouri Botanical Garden, where Palmer deposited his specimens, to substantiate this report. Three species of *Ruellia, R. strepens, R. pedunculata,* and *R. humilis,* are discussed, with supporting citations of Illinois specimens.

Ruellia *ciliosa* Pursh is a plant of the southeastern and Gulf-coastal regions. The writer follows M. L. Fernald in substituting the name *R. humilis* Nutt. for the northern-ranging species commonly found in Illinois, and formerly incorrectly known as *R. ciliosa* Pursh.

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CHEMISTRY

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* 1. Petroleum, Natural Gas, and Agriculture: GUSTAV EGLOFF, Universal Oil Products Company, Chicago.

* 2. Catalysis in the Oxidation of Oxalic Acid by Nitric Acid: J. H. REEDY, University of Illinois, Urbana.

* 3. Research Projects for Senior Chemistry Students: SISTER MARY MARTINETTE, B.V.M., Mundelein College, Chicago.

* 4. A Bomb in a Test-tube: G. FREDERICK SMITH, University of Illinois, Urbana. (slides)

* 5. Electron Microscope in Analytical Chemistry: ROBERT B. FISCHER, University of Illinois, Urbana. (slides)

* 6. Nutritional Studies on the Yeast, *Schizosaccharomyces pombe:* FRANK M. CLARK, University of Illinois, Urbana.

7. Chemistry of Synthetic Rubber: RUDOLPH DEANIN, University of Illinois, Urbana. (slides)

8. The Use of Partial Differentials for the Estimation of Errors in Volumetric Analysis: F. WM. CAGLE, JR., University of Illinois, Urbana.

*Not published.

THE USE OF PARTIAL DIFFERENTIALS FOR THE ESTIMATION OF ERRORS IN VOLUMETRIC ANALYSIS*

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This work was undertaken to determine what accuracy might be obtained in carefully conducted volumetric analysis. It is desirable to have such data in view of the immense popularity which volumetric schemes enjoy.

Development of Formulae

First let us develop partial differential expressions for probable error in volumetric analysis.[1] We shall derive these from the usual forms of the equations used for the calculations of volumetric results.

The following symbols shall have the meanings assigned:

S = Sample weight in grams.
ml = Volume of standard solution in milliliters.
e = Milliequivalent weight of substance sought or primary standard weighed.
N = Normality of standard solution.

If a sample of S (in grams) of a standard substance, whose milliequivalent weight is e, reacts stoichiometrically with a volume ml (in milliliters) of a solution, we may say that the normality, N, of the solution is given by:

$$N = \frac{S}{ml \times e} \qquad (I)$$

We may then write (e is a constant):

$$dN = \frac{1}{ml \times e}\partial S - \frac{S}{(ml)^2 \times e}\partial (ml) \qquad (II)$$

Now let us divide II by I to obtain expression III:

$$\frac{dN}{N} = \frac{\partial S}{S} - \frac{\partial (ml)}{ml} \qquad (III)$$

If a weighed quantity, S, of a sample of milliequivalent weight, e, should require ml milliliters of a standard solution of normality, N, for stoichiometric reaction, we may calculate percentage purity by formula IV:

$$\% = \frac{ml \times N \times e \times 100}{S} \qquad (IV)$$

By the scheme described above we can obtain expression V:

$$d\% = \frac{N \times e \times 100}{S}\partial (ml) + \frac{ml \times e \times 100}{S}\partial N - \frac{ml \times N \times e \times 100}{S^2}\partial S \qquad (V)$$

Combining expressions V and IV we derive VI:

$$\frac{d\%}{\%} = \frac{\partial (ml)}{ml} + \frac{\partial N}{N} - \frac{\partial S}{S} \qquad (VI)$$

If two solutions, one of volume, ml and normality, N, and the other of volume, ml′, and normality, N′, react stoichiometically, we may write expression VII:

$$N \times ml = N' \times ml' \qquad (VII)$$

From this we may write expression VIII:

*The material in this paper has been taken from a thesis presented to the Graduate School of the University of Illinois in partial fulfillment of the requirements for the degree of Master of Science (1945). It is presented with the permission of the Dean of the Graduate School and Professor G. L. Clark, under whose direction it was prepared.

$$dN = \frac{ml'}{ml}\partial N' + \frac{N'}{ml}\partial(ml') - \frac{N(ml')}{(ml)^2}\partial(ml) \qquad \text{(VIII)}$$

Dividing VIII by VII we obtain IX:

$$\frac{dN}{N} = \frac{\partial N'}{N'} + \frac{\partial(ml')}{ml'} - \frac{\partial(ml)}{ml} \qquad \text{(IX)}$$

It is necessary to give some consideration to the evaluation of the separate terms in equations III, VI, and IX. The term $\frac{\partial S}{S}$ is estimated from a knowledge of the sensitivity of the balance upon which the samples are weighed. The term $\frac{\partial(ml)}{ml}$ is estimated by careful weight calibrations of the burettes used. The pipets were standardized by the United States Bureau of Standards, and their error could be obtained directly from the certificate provided. In the case of equation IX, $\frac{\partial N'}{N'}$ is required. This is evaluated from previous calculations with equation III.

Application to Experimental Data

Table 1 contains data on the standardization of perchlorato-cerate solutions with samples of sodium oxalate. The over-all reaction is:

$$2\,H_2\,Ce\,(ClO_4)_6 + Na_2C_2O_4 = 2\,CO_2 + 2Ce(ClO_4)_3 + 6\,Na\,ClO_4$$

A sample of about 0.25 gram of pure dry sodium oxalate is accurately weighed on a balance of known sensitivity and dissolved in about 100 milliliters of 2N perchloric acid. This solution is then titrated (in the cold) with the unknown solution of perchloratocerate from a previously calibrated burette with the ferrous complex of 5-nitro-(1,10)-phenanthroline as the indicator. Samples 4 through 7 were taken from publication 2 listed in References with the knowledge and permission of the author.

Examples 1, 2, 3, and 4 in Table 2 concern the quantitative oxidation of sucrose by a perchlorato-cerate solution in 4N perchloric acid.[2] The over-all reaction is:

$$C_{12}H_{22}O_{11} + 26\,H_2Ce(ClO_4)_6 + 12H_2O = 11\,H_2CO_2 + CO_2 + 26Ce(ClO_4)_3 + 78\,HClO_4.$$

Examples 5, 6 and 7 in Table 2 represent data obtained for the titration of a weighed sample of purified ceric ammonium nitrate titrated with sodium oxalate in 2N perchloric acid.

Table 3 contains data on the standardization of a perchlorato-cerate solution with a standard solution of sodium oxalate and the reverse of this standardization.

It will be noted that in each table values of maximum, minimum, and average values for the terms evaluated are given. These are obtained by summing the individual terms to get the largest and the smallest summation and finally averaging these two values. This average calculated error is usually quite close to the observed variations in the analyses as inspection of the tabulated data will show.

References

1. If one is unfamiliar with this use of the partial differential expression, a standard textbook on calculus should be consulted. The following is recommended:
   Granville, Smith, and Longley, Elements of the Differential and Integral Calculus: Ginn and Company, New York, 1943. Revised Ed.
2. Smith, G. F., Cerate Oxidimetry: G. Frederick Smith Chemical Co., Columbus, Ohio, 1942.

Table 1.—Standardization of Cerate

	Standard $Na_2C_2O_4$ Wt. in grams	∂s	$\frac{\partial s}{s}$	Titrating solution Vol. in milliliters	$\partial(ml)$	$\frac{\partial(ml)}{ml}$	N
1.	0.2500	±0.0003	±0.0012	36.90	±0.04	±0.0011	0.1012
2.	0.2517	"	±0.0012	37.15	"	±0.0010	0.1011
3.	0.2503	"	±0.0012	34.81	"	±0.0011	0.1010
4.	0.1132	"	±0.0026	34.81	±0.06	±0.0017	0.04856
5.	0.1092	"	±0.0027	33.63	"	±0.0017	0.04849
6.	0.0883	"	±0.0034	27.16	"	±0.0022	0.04855
7.	0.0958	"	±0.0031	26.46	"	±0.0023	0.04856

Table 2.—Experimental Data inter-

	Wt. of sample g.	∂s	$\frac{\partial s}{s}$	Titrating solution Vol. in milliliters	$\partial(ml)$	$\frac{\partial(ml)}{(ml)}$	N
1.	0.01250	±0.0003	±0.024	8.90	±0.06	±0.0067	0.1051
2.	"	"	"	"	"	"	"
3.	0.03371	"	±0.0089	24.50	"	±0.0025	"
4.	"	"	"	24.44	"	"	"
5.	2.5000	"	±0.00012	44.19	±0.04	±0.00091	0.1031
6.	"	"	"	44.16	"	"	"
7.	"	"	"	44.18	"	"	"

Table 3.—Experimental Data inter-

	ml′	$\partial(ml')$	$\frac{\partial(ml')}{ml'}$	ml	$\partial(ml)$	$\frac{\partial(ml)}{ml}$	N′	$\frac{\partial N'}{N'}$
1.	23.01	±0.02	0.00087	25.00	±0.002	±0.00008	0.1051	0.002
2.	23.02	"	"	"	"	"	"	"
3.	23.01	"	"	"	"	"	"	"
4.	47.02	"	0.00042	50.00	"	±0.00004	0.1012	0.001
5.	"	"	"	"	"	"	"	"
6.	47.03	"	"	"	"	"	"	"

SOLUTIONS WITH PRIMARY STANDARD $Na_2C_2O_4$

Max.	$\frac{dN}{N}$ Min.	Av.	Max.	dN Min.	Av.
$\pm 2.3 \times 10^{-3}$	$\pm 0.1 \times 10^{-3}$	$\pm 1.2 \times 10^{-3}$	$\pm 2.3 \times 10^{-4}$	$\pm 0.1 \times 10^{-4}$	$\pm 1.2 \times 10^{-4}$
± 2.2 "	± 0.2 "	± 1.2 "	± 2.2 "	± 0.2 "	± 1.2 "
± 2.3 "	± 0.1 "	± 1.2 "	± 2.3 "	± 0.1 "	± 1.2 "
$\pm 4.3 \times 10^{-3}$	± 0.9 "	± 2.6 "	$\pm 2.1 \times 10^{-4}$	$\pm 0.44 \times 10^{-5}$	± 1.3 "
± 4.4 "	± 1.0 "	± 2.7 "	± 2.1 "	± 0.48 "	± 1.3 "
± 6.6 "	± 1.2 "	± 3.9 "	± 3.2 "	± 0.58 "	± 1.9 "
± 6.4 "	± 0.8 "	± 3.6 "	± 3.1 "	± 0.39 "	± 1.7 "

PRETED BY MEANS OF EQUATION VI

$\frac{\partial N}{N}$	% (Approx.)	Max.	$\frac{d\%}{\%}$ Min.	Av.	Max.	d% Min.	Av.
± 0.0020	98.48	± 0.022	± 0.012	0.017	± 2.2	± 1.2	± 1.7
"	98.49	"	"	"	"	"	"
"	100.28	± 0.013	± 0.0044	± 0.008	± 1.3	± 0.4	± 0.8
"	100.52	"	"	"	"	"	"
± 0.00052	99.92	$\pm 1.5 \times 10^{-3}$	$\pm 0.27 \times 10^{-3}$	$\pm 0.9 \times 10^{-3}$	± 0.15	± 0.027	± 0.09
"	99.88	"	"	"	"	"	"
"	99.91	"	"	"	"	"	"

PRETED BY MEANS OF EQUATION IX

N	Max.	$\frac{dN}{N}$ Min.	Av.	Max.	dN Min.	Av.
0.09673	± 0.0022	± 0.0018	± 0.002	$\pm 2.1 \times 10^{-4}$	$\pm 1.7 \times 10^{-4}$	$\pm 1.9 \times 10^{-4}$
0.09678	"	"	"	"	"	"
0.09673	"	"	"	"	"	"
0.09517	± 0.0014	± 0.0005	± 0.0009	$\pm 1.3 \times 10^{-4}$	$\pm 0.4 \times 10^{-4}$	$\pm 0.8 \times 10^{-4}$
"	"	"	"	"	"	"
0.09518	"	"	"	"	"	"

THE CHEMISTRY OF SYNTHETIC RUBBER*

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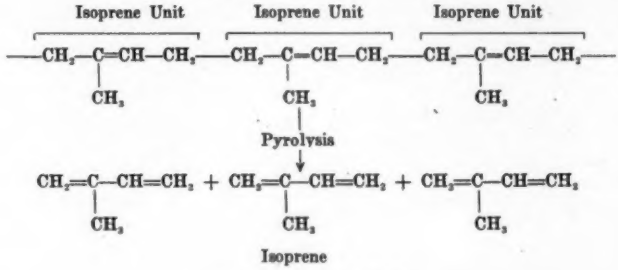
Introduction

In 1835 an obscure German chemist named Himly heated a sample of natural rubber and distilled out a volatile colorless liquid which was later named isoprene.[1]

During the next half century, several men reported the repolymerization of isoprene.[1, 2, 3] Then in 1882 Sir William Tilden suggested that if another and more economical source of isoprene were available, commercial polymerization of isoprene to synthetic rubber might be possible.[3]

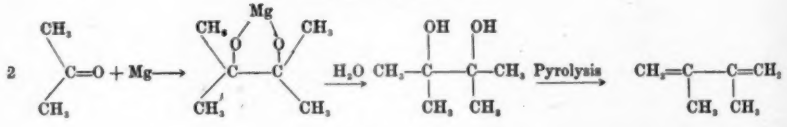
While isoprene itself was not readily available in large quantities, several similar substances were.

Pyrolysis of Natural Rubber

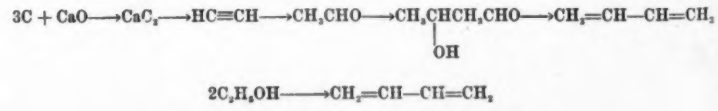


Preparation of Dienes

2,3-Dimethylbutadiene



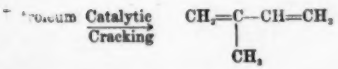
Butadiene



*Most of the investigations discussed in this report were carried out under the sponsorship of the Reconstruction Finance Corporation, Office of Rubber Reserve, in connection with the Government Synthetic Rubber Program. The author has tried to give credit to the many research chemists of the industrial, research foundation, and university laboratories cooperating with this program, whose work is summarized briefly here.

**Present address: Allied Chemical and Dye Corporation, Morristown, New Jersey.

Isoprene

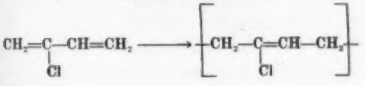


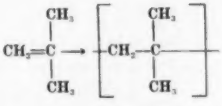
For example, bimolecular reduction of acetone produced pinacol hydrate, which was then dehydrated to 2, 3-dimethylbutadiene; this formed the basis of the German synthetic "Methyl Rubber" during the first World War. Later 1, 3-butadiene became available from several sources in large quantities and is now the most important material in synthetic rubber production. Very recently even isoprene became commercially available, but contemporary industrial practice heavily favors the use of butadiene for general purpose synthetic rubber.[4]

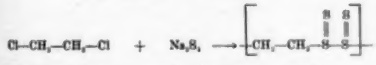
Several other types of synthetic rubber are produced in small amounts because they have special physical properties which make them useful in particular applications.[4]

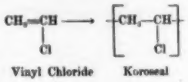
For example, Neoprene has high oil resistance, and many of its uses in rubber hose, gloves, industrial shoes, and power transmission belts depend upon this. Vistanex or Butyl Rubber is very impermeable to gases and resistant to aging, making it valuable for use in inner tubes. Thiokol's uses for rubber hose and cable insulation depend upon its resistance to aging and solvents. Koroseal provides transparent elastic films for many purposes. Silicone greatly outlasts other rubbers in high temperature gaskets and similar uses. The present discussion, however, will be limited to butadiene polymers, which form the major portion of synthetic rubber production today.

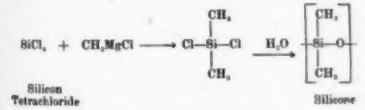
Other Synthetic Rubbers







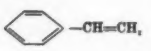


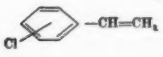


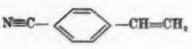
The GR-S Polymerization System

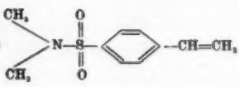
The physical properties of butadiene synthetic rubber are improved greatly by copolymerizing butadiene with various vinyl comonomers.

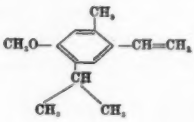
Comonomers

Styrene 

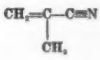
Monochlorostyrene 

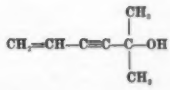
p - Cyanostyrene 

p - (N,N - Dimethylsulfonamido)styrene 

2-Methyl - 4-methoxy - 5-isopropylstyrene 

Acrylonitrile

Methacrylonitrile 

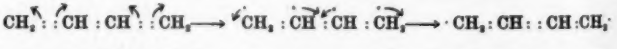
Dimethyl Vinylethinyl Carbinol 

While styrene is the most common comonomer in GR-S rubber, many substituted styrenes have been used experimentally to determine whether they may produce improved synthetic rubber.[5] For example, monochlorostyrene is available in moderate quantities and has produced tires which wear considerably longer than GR-S. One *p*-cyanostyrene copolymer produced excellent preliminary tests, but this comonomer is so difficult to prepare that no further studies of it have been attempted. Attempts to produce superior synthetic rubber have led to the investigation of even such complex comonomers as *p*-(N, N-dimethylsulfonamido) styrene and 2-methyl-4-methoxy-5-isopropylstyrene.

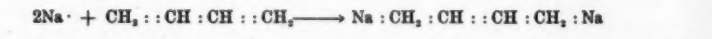
Acrylonitrile is another comonomer frequently used in industry. Preliminary studies indicate that methacrylonitrile may be far superior for tires, but this comonomer is practically unavailable for further tests at present.[6] Dimethyl vinylethinyl carbinol is an example of another comonomer which may offer the possibility of improving physical properties.[7]

Butadiene copolymerizes very slowly, even under the influence of heat and pressure. With the addition of proper catalysts—or activators—the polymerization reaction may be

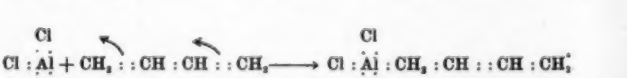
Catalysis of Butadiene Polymerization

Thermal 

Alkali Metal



Metal Alkyl

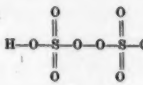
"Acidic" Metal Halide 

Free Radical

carried out readily under a wide variety of conditions.

Thus alkali metals,[8] alkali metal alkyls,[9] or so-called "acidic" metal halides[10] may be used to activate the carbon-carbon double bonds and thus catalyze extremely rapid butadiene polymerization. The synthetic rubber industry has generally preferred to use activators which decompose tc yield free radicals which initiate the polymerization reaction.

Free Radical Activators

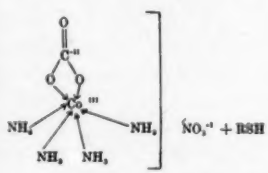


$K_3Fe(CN)_6 + RSH$

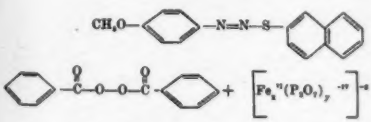
$H_2O_2 + [Fe_x^{III}(P_2O_7)_y^{-n}]^{-z}$

ROOH + Other Ingredients

$O_2 + \cdot[Fe_x^{II}Fe_y^{III}(P_2O_7)_z^{-n}]^{-z} + RSH$



$NO_3^- + RSH$



While a number of types of activators have been developed,[7, 11] the chemistry of activation is very obscure and poorly understood. A survey of some of the activators frequently used indicates that most of them are good oxidizing agents, and suggests that initiation of polymerization may involve some oxidation reaction; but the specificity of these activator systems emphasizes the complexity and obscurity of this reaction.

The polymerization may be carried out in the vapor or bulk (liquid) phase,[8] in solution,[9, 10] suspension, or emulsion[12].

While the Russian synthetic rubber industry has concentrated upon vapor or liquid phase polymerization of butadiene using sodium catalyst, American and German synthetic rubber production is based upon emulsion copolymerization of butadiene with other comonomers, using free radical activators.

To disperse the organic monomer liquid in water various emulsifiers have been used.

In America ordinary fatty acid soaps[13] and certain rosin soaps (essentially sodium dehydroabietate)[14] are most commonly used, and other emulsifiers such as amine soaps have also been investigated.[15] In Germany, scarcity of natural soaps led to the use of various synthetic emulsifiers, such as Mersolat and Nekal.[16]

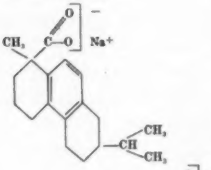
Polymerization Media

VAPOR	BULK	SOLUTION	SUSPENSION	EMULSION
Monomer	Monomer Comonomer	Monomer Comonomer	Monomer Comonomer	Monomer Comonomer
		Solvent	Water Protective Colloid	Water Emulsifier
Catalyst	Catalyst	Catalysts	Catalysts	Catalysts Modifier

American Emulsifiers

Sodium Stearate $CH_3(CH_2)_{16}C(=O)-O^- Na^+$

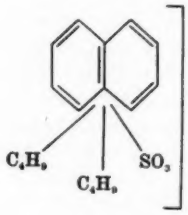
Sodium Dehydroabietate



Dodecylammonium Acetate $CH_3(CH_2)_{11}NH_3^+ \; CH_3C(=O)-O^-$

German Emulsifiers

Nekal



Mersolat $C_{14-17}H_{29-35}SO_3^- Na^+$

The GR-S Polymerization Reaction

When soap dissolves in water it forms plate-shaped or spherical micelles.[17]

The monomer is emulsified as droplets of organic liquid surrounded by soap molecules and suspended in the aqueous phase. Monomer in these droplets diffuses gradually into the soap micelle, where intimate interphase contact permits the activators to initiate the polymerization reaction. As the reaction proceeds, continuous diffusion of monomer into the micelle and polymerization there converts the micelle into a polymer-monomer particle surrounded by a layer of soap molecules which stabilize the latex. Eventually the monomer droplets are all consumed, and only the polymer-monomer particles remain. Then further polymerization of the monomer decreases its concentration in the particles, and the rate of polymerization decreases gradually as the reaction approaches completion.[18]

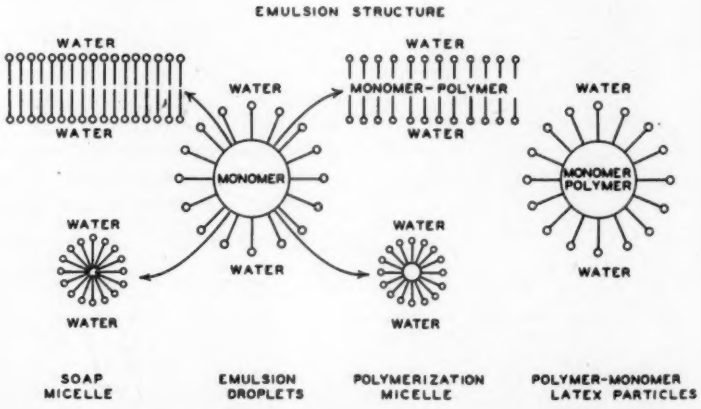


Fig. 1

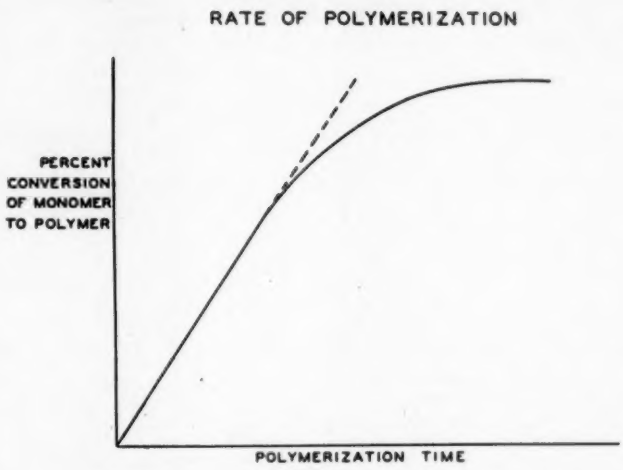
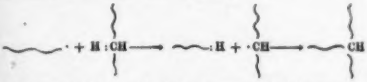
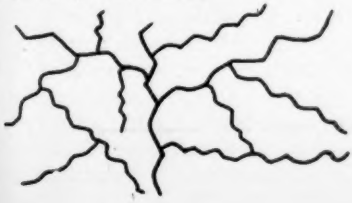


FIG. 2

As the polymerization reaction proceeds, the concentrations of the reactants and the physical conditions of the system change, and the molecular structure and physical properties of the resulting polymer vary continuously.[19] The growing polymer molecule may attack another polymer molecule, probably at the carbon-hydrogen bond adjacent to a vinyl group, and this chain transfer reaction produces a new free radical which grows into a cross-linked three-dimensional molecule.[20]



Repetition of this cross-linking reaction produces a "pincushion" shape polymer molecule.



If a modifying agent is used to regulate the growth of these cross-linked molecules, it terminates the growing molecules by a chain transfer reaction.[21]

As the modifier is consumed during the reaction, its concentration decreases and its effectiveness becomes less and less. The decreased frequency of chain transfer permits the molecular weight to rise, but it also permits more extensive cross-linking to form large three-dimensional molecules which are insoluble in benzene and are known as gel.[22] As the modifier concentration is decreased, gel formation increases rapidly. Molecular weight, which is measured by the intrinsic viscosity of the dilute benzene solution, increases as the modifier concentration decreases, as long as the rubber is entirely soluble; but when part of the rubber is excluded from the benzene solution as gel, the intrinsic

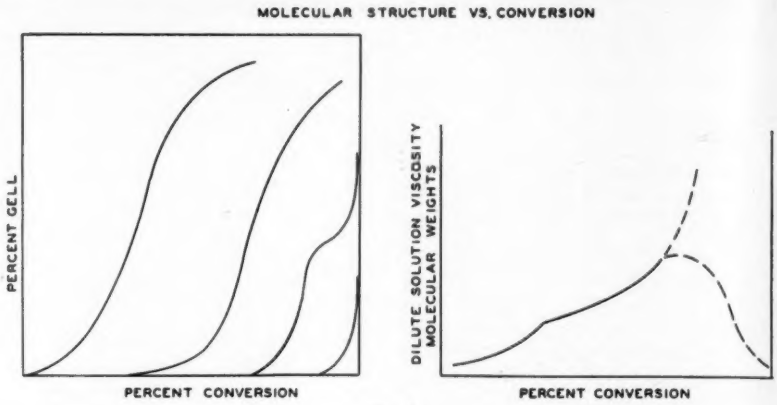


FIG. 3.

viscosity drops, while the actual molecular weight probably rises very rapidly.

PHYSICAL PROPERTIES OF GR-S SYNTHETIC RUBBER

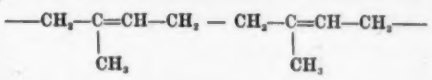
Corresponding with these changes in molecular structure there is a gradual change in physical properties.[23] As the molecular weight increases, the synthetic polymer resembles natural rubber more closely and the physical properties improve. Extensive gel formation however produces a structure quite different from natural rubber, and has a detrimental effect on physical properties. At high conversions, when gel formation becomes serious, Mooney viscosity increases, while processability and ease of breakdown decrease; these all indicate the formation of tough rubber which is difficult to process. Rebound (resilience) improves; but tensile strength, elastic elongation, rate of crack growth during flexing, and modulus all become worse, signifying a deterioration of rubber-like properties. Thus polymerization conditions must be carefully controlled to produce polymers with the desired physical properties.

Even at its best, however, synthetic rubber is very different from natural rubber, and much of this difference is believed to be due to differences in molecular structure.[24]

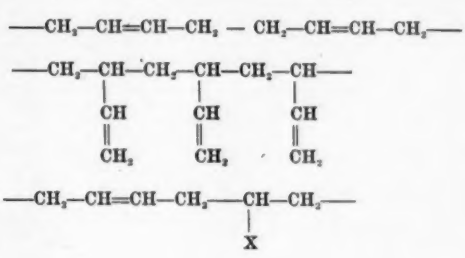
Natural rubber contains a 2-methyl group placed at regular intervals along the polymer chain, while polybutadiene does not. The position of monomer units in the polymer chain is very regular in natural rubber, whereas it is a random mixture of 1, 2- and 1, 4-addition in synthetic rubber, and would be even worse in synthetic polyisoprene. The occasional units of vinyl monomers add to the heterogeneity of the synthetic rubber molecule. Furthermore, in natural rubber the arrangement of the atoms at the double bonds is always *cis*, while in synthetic rubber it is a mixture of *cis* and *trans*.[25] Natural rubber contains long linear molecules, while synthetic rubber contains a heterogeneous mixture of cross-linked three-dimensional molecular structures. Finally the molec-

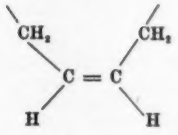
Molecular Differences Between Natural and Synthetic Rubber

Natural Rubber

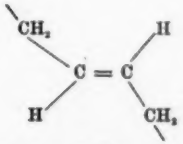


Synthetic Rubber





Cis



Trans

ular weight distribution is very different in the natural and synthetic polymers: natural rubber is more homogeneous, has less low-molecular weight material and a higher average molecular weight; while synthetic rubber has more low-molecular weight material, is more heterogeneous, and has a lower average molecular weight.[22, 26] All these differences contribute to the great difference between the two in processability and physical properties.

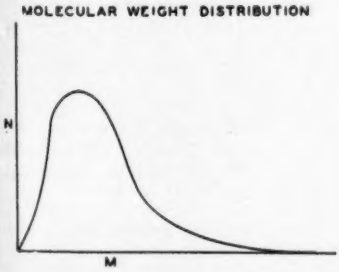


FIG. 4

Consequently we cannot call butadiene polymers "rubber substitutes" in the sense that they must resemble and replace natural rubber. Rather, we must recognize that synthetic polymers are distinctly different from natural rubber, and that therefore their processing, physical properties, and resulting uses must be designed to use them to best advantage, rather than merely to make them a bad substitute for something entirely different. During the war years, the urgent need for a rubber substitute prevented this functional approach; and consequently the future of synthetic rubber, in competition with natural rubber, is still uncertain. On the other hand, the special synthetics, which were developed and applied specifically

where they were superior, are certainly here to stay, and will become more and more important as they are developed further by industrial research.

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4. Lake Michigan Ports—A Classification by Items of Trade: JOHN W. REITH, Northwestern University, Evanston.

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* 7. Some Aspects of the Northeastern Illinois Dairy Region: GEORGE C. DE LONG, University of Illinois, Urbana.

* 8. Fundamentals of Mineral Conservation: WALTER H. VOSKUIL, Illinois State Geological Survey, Urbana.

* 9. Urban Settlements on Hokkaido: ALDEN CUTSHALL, University of Illinois, Urbana.

10. The Pottery Industry in McDonough and Warren Counties, Illinois: JOHN FREDERICK LOUNSBURY, University of Illinois, Urbana.

11. Teaching of Conservation of Natural Resources in Illinois Colleges and Universities: TROY L. PÉWÉ, Augustana College, Rock Island. (Presented at 39th Annual Meeting.)

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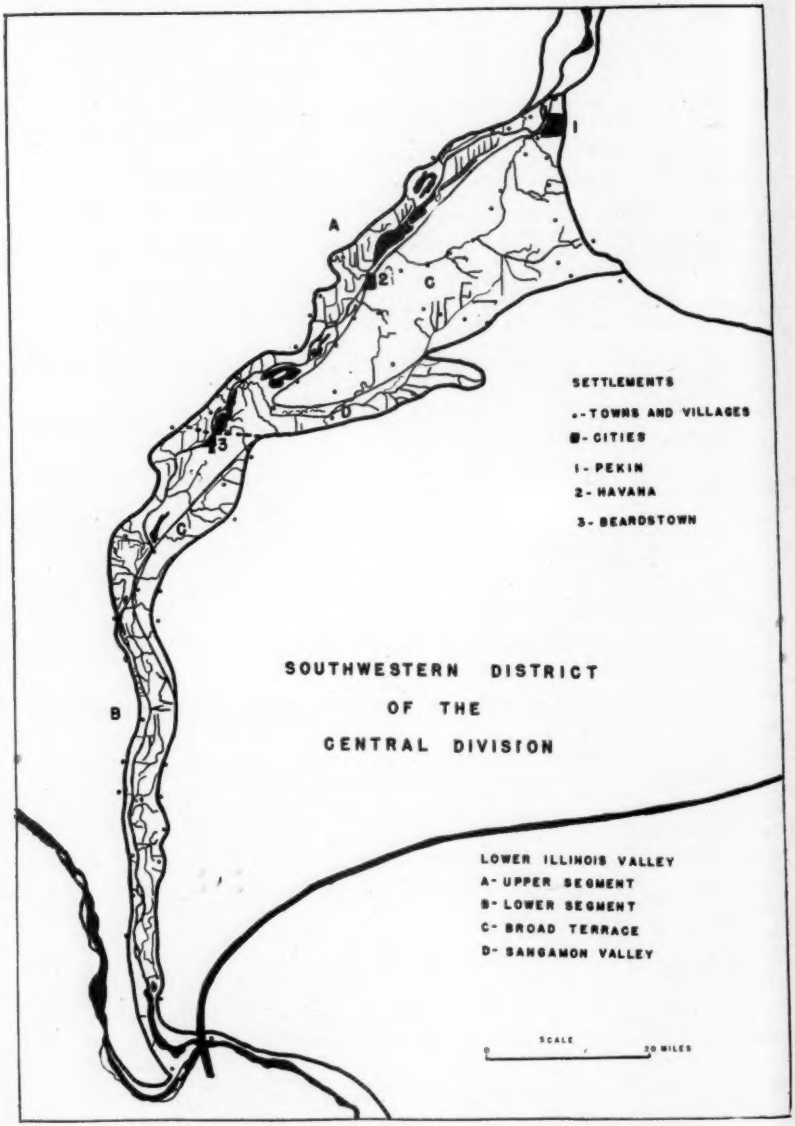

FIG. 1.—Occupance patterns of the Lower Illinois Valley.

OCCUPANCE PATTERNS OF THE LOWER ILLINOIS VALLEY

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From the confluence of the Kankakee and the DesPlaines rivers to the Mississippi River, approximately 250 miles to the southwest, flows the Illinois River in a valley which is one of the significant features of the geographic patterns of the State. The several sections of the valley which extend entirely across the Central Division of Illinois form the northern and western boundaries of the Eastern and Southwestern Districts. From the Kankakee-DesPlaines confluence to the Bureau bend is the Upper Illinois Valley whereas the Middle Illinois Valley extends from Bureau to Pekin. These two sections are a part of the Eastern District. The Lower Illinois Valley, which extends from Pekin to the Mississippi, a distance of 140 miles, is a portion of the Southwestern District (fig. 1).

The Lower Illinois Valley is composed of two well-marked and contrasting segments. The Upper Segment, which extends from Pekin to Beardstown, consists of a lake studded valley trough occupied by the braided river channel and a broad series of sand terraces interspersed with poorly drained depressions. These sandy terraces, with a maximum width of twenty miles, occupy the left side of the valley from the Shelbyville moraine to the Sangamon River whose meandering course has been canalized and straightened from its confluence with Salt Creek to the Illinois River. The Lower Segment, from Beardstown to the Mississippi River, consists of a north-south valley trough which becomes narrower and deeper with distance down stream until it swings away from the narrow ridge that is Calhoun County and merges with the wide eastward trending Mississippi trough.

Cultural Patterns

The Lower Valley is decidedly one of the problem areas of the State as well as a zone of conflict concerning the solution of those problems. The conflicting agents include the State, the twelve counties which line both sides of the river, several organized drainage districts, and the Army Engineers. The latter are concerned with drainage, navigation, and flood control.

Within the area lives a small dominantly rural population. Pekin, at the northern apex of the valley with a population of about 20,000, is the largest urban center, whereas, Havana (4000) and Beardstown (6500), river towns spaced at thirty mile intervals down the valley, are the only other towns with populations over 2500. Twenty incorporated towns of less than 2500 people, thirty unincorporated villages, and scattered rural habitations make up the rest of the population pattern.

Human interests and activities are concerned largely with the land of the valley and with the river itself. Outside of Pekin and the Orchard

and Kingston Mines across the river, manufacturing and mining are of little significance. Farming dominates the valley with as many as one quarter of the gainfully employed population engaged in that activity. The Upper Segment of the valley is a commercial grain area and the Lower Segment an area of general mixed agriculture, which in general is the less prosperous of the two as is indicated by federal income tax returns. Based upon 1940 returns, before the base was lowered and the rates increased to meet wartime conditions, less than 8% of the population of the Lower Valley received a yearly income sufficiently large to be taxed by the federal government. This figure varied from a high of 13% in the Pekin district of the Upper Segment to a low of less than 3% in the lower portion of the Lower Segment.

There is no other area, with the possible exception of the Ohio Border,where fishing and lumbering engage the activity of as many people as in the Lower Illinois valley. The braided and impounded Upper Segment is a more notable area for commercial fishing than the Lower Segment. These river activities do not produce large incomes nor do they contribute to a high standard of living. In a land of alluvial river bottoms, poor drainage, and flood menace, economic returns are low and the handicaps numerous. Although the river is a portion of a navigational link between the Gulf of Mexico and the Great Lakes, no advantages accrue to the Lower Valley as the decadent river towns attest. Flood is a constant menace to the towns and rural areas alike, and drainage of the low flat lands is a necessity to agricultural utilization over much of the area.

The Upper Segment

Although alike as far as the general problems are concerned, the Upper Segment of the valley presents some sharp contrasts to the Lower Segment. In the former, population and transportation patterns emphasize the two contrasting physical features, the valley trough and the broad terrace. The three largest towns, Pekin, Havana, and Beardstown, are evenly spaced at positions where the broad terrace meets a narrow portion of the river thus affording a satisfactory crossing of the valley trough by railroads and highways. Seven railroads and two highways focus on Pekin on its terrace site between the Shelbyville moraine and the valley bottom. Four of the railroads cross the terrace from the south, and two of them cross the river as does one highway.

Havana is served by several railroads, one of which terminates on the river front. The highway, however, crosses the river there and follows the river bluff both up and down on the west side of the river. At Beardstown, at the lower end of the Upper Segment, both the highway and two railroads cross the river.

Small river front towns are conspicuously lacking in the Upper Segment of the valley. On the broad terrace, alignments of small towns and villages conform to the railroad pattern. One follows the inner edge of a sandy terrace between Pekin and Havana, another occupies the outwash of the Shelbyville moraine

at the extreme eastern margin of the area, and a scattered group of village alignments radiate southward from Havana. In the valley trough a line of bluff-side villages connected by a valley highway occupy tributary valley mouth sites. However, the largest tributary, Spoon Creek, which joins the Illinois River directly opposite Havana, is not the site of a town.

VALLEY BOTTOM OCCUPANCE

Although the Upper Segment of the valley is a portion of the cash grain area of the State, a variety of land uses prevail. On the alluvial bottom lands, drainage is the outstanding problem. Organized drainage districts have dug ditches, built levees, and installed pumping stations to improve portions of the valley bottom which are consistently in corn crops. Improved valley bottom drainage, however, does not prevent or control floods and much of the land is unused. Lakes and vegetation choked sloughs, some of which are set aside as wild life refuges, are conspicuous elements of the valley bottom, whereas roads and farmsteads are limited to the bluff side margins and to the intermittent areas that have been ditched and drained.

BROAD TERRACE OCCUPANCE

The broad terrace on the left side of the Upper Segment presents a different pattern of occupance. Well-drained sandy terraces contrast with adjacent sloughs and depressions in which drainage ditches and levees have been constructed by organized drainage districts. The Sangamon and Mackinaw rivers and Quiver Creek flow through portions of the depressions which divide the area into a series of terraces. The Mackinaw describes a sharp arc from the Shelbyville moraine to the Illinois River about two and one-half miles below Pekin, separating the terrace site of the city from the remainder of the sandy outwash which lies along the margin of the moraine from the Illinois River to the vicinity of Emden. Three of the railroads follow this terrace to Pekin, and along them is one of the alignments of villages.

From the Mackinaw River to Quiver Creek, about four miles above Havana, is a crescent-shaped sandy terrace that is separated from the outwash area adjacent to the Shelbyville moraine by an extensive depression which has been ditched and drains into Quiver Creek. The railroad from Pekin to Havana follows the inner margin of the terrace along which the towns are aligned at a distance of four to six miles from the river. Farmsteads, many of which are old, are scattered over both terrace and depression. The cash grain farming of the Grand Prairie extends over the Shelbyville moraine and into the Upper Segment of the valley. Corn is the major crop although small grain, especially wheat, is much more important on the lighter soils of the terraces than it is on the heavy soils of the depressions. About 4500 acres of the sandy terrace, above Quiver Creek between Forest City and Clear Lake on the valley bottom, are given over to the Mason County State Forest.

From Quiver Creek to the Sangamon is another extensive terrace which is interrupted in several places by depressions which have

been ditched into the Sangamon. At a point near the upper end, where the Illinois River flows against the terrace, is the town of Havana from which railroads and highways radiate. Although there is much unused land, cash grain farmsteads are scattered over the entire terrace.

The southern edge of the broad terrace is marked by the Sangamon River, which enters the area from the south and follows the flat bottom of the narrow valley trough westward to the Illinois River. The meandering course of the river has been straightened and, except for the lower ten miles, has been enclosed by levees leaving oxbows and meander scars scattered over the valley floor. The boundary between Mason and Cass counties, which followed the original course of the river, now follows a devious path back and forth across the river. Roads and farmsteads are not numerous on the valley floor of the Sangamon.

The Lower Segment

Beardstown marks the end of the Upper Segment and the beginning of the Lower. At that point the valley narrows to about ten miles in width, and the levees, which enclose the valley trough throughout most of its lower course, are established on both sides of the river. On the right side they begin at Fulton County line about twenty miles above Beardstown. On the left side the levee begins in the Sangamon Valley and extends to the river front entirely enclosing the valley floor on which Beardstown is situated. Drainage from the area is pumped from ditches into the river at the site of the new LaGrange lock and dam six miles below the town.

From a width of ten miles the Lower Segment narrows to less than two and one-half miles and the river bluffs rise to several hundred feet above the valley floor. The river pursues a direct course on the right side of the valley leaving only a narrow strip of valley floor on that side, especially in the lower narrow course. Except for LaMoine River and McGees Creek in the upper portion of the Segment, the tributaries on the right side of the valley consist of short narrow valleys locally known as "hollows." The floor on the left side of the valley is considerably wider and is interrupted at regular intervals by Indian, Apple, Big Sandy, and Macoupin creeks.

The left valley floor is protected by a levee from Beardstown to Macoupin Creek, but since the river flows on the right side of the valley only the upper twenty-five miles of that side are protected. Ditches and pumping stations drain much of the valley bottom on both sides of the river except in times of high water on the Illinois when much of the bottom land is flooded. Corn and hay crops are produced on the alluvium of the valley bottom, although graded unsurfaced roads and farmsteads are distributed over much of the bottom land, towns and villages and surfaced highways occupy the better drained position at the margin of the valley trough or the bluffs just above the valley.

Meredosia (1000) and Naples (260) are river front towns on a low sandy terrace that extends about twenty-five miles down the left side of the valley from Beardstown. A railroad crosses the river at Meredosia as does another at a point five

miles below Naples. The rest of the villages are aligned on the bluff-side highway in the mouths of tributary valleys where spring freshets cause considerable damage.

At Hillview in the valley of Hurricane Creek, forty miles above the Mississippi, a railroad crosses the Illinois River directly to Pearl in Hill Creek valley. Twelve miles farther down the valley at Eldred, a railroad spur enters the valley by way of a tributary, likewise known as Hurricane Creek, turns southward and terminates on the valley bottom nine miles farther down the valley opposite the town of Hardin, the county seat of Calhoun County. A large movable elevator type bridge, the last one down the valley, and an improved highway cross the valley there. In this manner the railroad serves Calhoun County, which is the only county in the state without a railroad within its boundaries.

Because of the better drained conditions of the right side of the valley the major highway has been constructed on that side, but it does not follow the valley all of the way. At Hardin, about fifteen miles above the Mississippi the highway crosses the valley on the bridge noted above and continues southward to Pere Marquette State Park and the town of Grafton at the Illinois-Mississippi confluence. Pere Marquette State Park occupies about seven square miles on the wooded bluffs at the left side of the lower end of the Illinois Valley.

Extra-Regional Relationships

Grafton, a town of 1100, holds the same relative position to the Illinois Valley that Cairo holds to the Ohio, both of which are indicative of the general significance of rivers as highways in America. Like the Ohio, the Illinois River is part of a national navigational system under the jurisdiction of the Army Engineers who dredge its channel and erect dams and levees. As such the Lower Illinois Valley, along with the rest of the river, assumes national significance. That the national relations are of little consequence to the local area is obvious. Like the Ohio, the Lower Illinois Valley is subject to high water and infrequent disasterous floods; these are of significance to the local area. The river is used for sanitary drainage as well as for navigation on an extra-regional basis; it is a source of water supply and fish within the area. It is quite unsatisfactory to consider the Lower Valley as a corridor in the complete geographic sense, yet many of the corridor problems are there. The major one is the conflict of indigenous and extra-regional interests. Although indigenous interests are in many instances based upon unfortunate natural environmental associations which result in poverty, it is unjust to condemn without exhaustive consideration of all facts concerned and without offering advantageous alternatives. The extent to which occupance is satisfactorily readjusted to natural environmental conditions by all people concerned, the greater will be our state and national advancement toward a long enduring maturity. River valleys are included among our problem areas, and the Lower Illinois Valley is not one of the exceptions.

THE POTTERY INDUSTRY IN McDONOUGH AND WARREN COUNTIES, ILLINOIS*

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The production of clays and clay products in Illinois is valued at approximately $32,000,000 annually. This is the third largest mineral industry in the State following coal and petroleum. In 1946, the production of pottery and whiteware in Illinois accounted for about one-third of the total value of all clay products made in the state. Illinois is surpassed by Ohio, New Jersey, New York, California, and Pennsylvania in the manufacture of pottery.

The potteries in Illinois are concentrated in two general areas. The largest, in terms of numbers of establishments, is the Chicago area. In Chicago itself, Antioch, Dundee, Crystal Lake, and Elgin, there are eighteen concerns manufacturing a variety of products. It can be generally stated that the large market and excellent transportation are the chief factors for the concentration of potteries in this area. The potteries in smaller towns near Chicago utilize the large market, but lower taxes, intelligent labor and, in some cases, financial support from the towns, influenced their establishment in the perimeter of Chicago.

The remaining potteries in the state, with the exception of the Case Manufacturing Company in Robinson which produces sanitary ware, are located in western Illinois.

The potteries in western Illinois can be divided into three groups determined by factors which controlled their original establishment. The first group are those potteries located in White Hall. The basic and dominant condition which determined their location was the existence of excellent stoneware clays in and around White Hall and the proximity of coal. These clays were found in abundance and in such a state that mining could be done easily. The existing clay banks attracted potters who began to manufacture stoneware, and the two potteries of today, Ruckell's Pottery Company and The White Hall Sewer Pipe and Stoneware Company, are the result of these natural resources. Also the establishment of the Illinois China Company in Lincoln can be traced to the stoneware plant in Roodhouse where again the fine White Hall stoneware clays were utilized.

The second group of potteries is located farther north at Macomb and Monmouth. Again, clays of the Pottsville formation, found in the vicinity of Colchester, were of such quality that potters were attracted, and they established potteries using only the local clays. Because of the potteries, a concentration of semi-skilled workmen gradually became concentrated in this area, and the town of Macomb and adjacent villages, with a large number of their population engaged in clay working industries or indirectly dependent

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upon them, became ceramic conscious. With existing plants and trained labor, it was a natural step to improve upon their products, and gradually fine clays and materials were brought in. However, the local clay was the dominant factor in their early establishment. The potteries of this group are the Macomb Pottery, Illinois Electric Porcelain in Macomb and Western Stoneware in Monmouth.

The third group consists of diversified potteries which have no common physical factor in their early establishment. The physical environment played a subordinate role and human factors were decisive in their location. These varied factors would have to be discussed as they apply to the individual pottery. This group consists of the Abingdon Potteries Incorporated located in Abingdon and the Morton Pottery Company in Morton.

The Potteries of Monmouth and Macomb

The Macomb Pottery

In Macomb the former Buckeye Pottery Company, makers of stoneware, was taken over in 1939 by the Haeger Potteries. The name changed to the Macomb Pottery and it began to make the Haeger style of art pottery. The old Buckeye Pottery made only stoneware products and utilized only the local clay found in abundance near Colchester. The competition from China and finer grades of earthenware had forced the Buckeye Pottery Company into the state of bankruptcy in 1938.

Over sixty years ago in Dundee, Illinois, the Haeger family began to manufacture brick using the local clays. Gradually the kilns were used in burning other forms of pottery until today no brick is made at all and the entire output is art pottery.

Art pottery, a relatively new trend, is noticeable in the pottery field today, and it can generally be stated that the comparatively newer potteries produce art ware. In the older pottery centers of Ohio and New Jersey, more dinnerware and sanitary ware are made. In these older potteries a tremendous amount of this type of ware was and is produced, and consequently the more recent potteries had a greater commercial opportunity in the making of art pottery. This can be seen in the great numbers of art potteries in the southern California area. This area is the most recent pottery center to be developed and at present is experiencing a rapid expansion.

Another factor in the more recent impetus in the the manufacture of art ware is the result of the War. The seizure of Moravia, Bohemia, and Slovakia by Germany decreased our imports from those areas as early as 1939. Later, at the outbreak of the war, little pottery made in the European centers came to this country. Also during this period changes in duty rates and regulations governing imports further decreased the small amount of European pottery coming to this country. The war, of course, also halted all importation of Japanese ware and seriously decreased that made in China. The lack of foreign products and resulting competition resulted in a large expansion of the ceramic industry in this country, especially in the gift and art ware fields. Many potteries began to make art ware in addition

to their main products, and new potteries sprang up to meet the domestic need.

Haeger Potteries diversified its line to include a great deal of ware of the type formerly made in Japan and Czechoslovakia. The pottery experienced a rapid rise in production and soon outgrew its building in Dundee. The Buckeye Pottery in Macomb, with its buildings and machines intact, and the semi skilled labor in the city, was therefore an excellent location in which to overflow. Further, Macomb, from its beginning, has been ceramic conscious due to the fine local clay and relatively large clay working population. The city was anxious for the pottery to resume operation after the Buckeye pottery declared bankruptcy and made a cash donation to the Haeger Pottery to take over the plant.

The Haeger Potteries are the world's largest producers of art ware and the markets are nation wide. Some pottery is exported to Canada, Hawaii, Phillipines, South America, England and other countries of the world. Sales offices are located throughout the country, and the majority of the pottery is sold through their own sales organization; jobbers market a small amount. The finished products are transported primarily by the C. B. & Q. Railroad. Trucks transport an ever increasing amount, usually when the distances are short.

The plant employs an average of 160 people. The amount of local labor is practically 100 percent, however, a small number of supervisors and administrators came from the pottery in Dundee. The skilled workmen represent about 15 percent of the total labor. They are for the most part mould makers and decorators. The designers, of which some are internationally famous, are located in Dundee, not in Macomb. Their designs are sent to Macomb where they are utilized in producing Haeger pottery. The plant has the capacity to produce 8,000 pieces of art pottery daily.

MATERIALS USED IN ART POTTERY

Years ago only the Colchester clay was the basic material used in the manufacture of stoneware. But today, materials are brought in from afar and the local clays are no longer used. The factory is situated on the Chicago, Burlington, and Quincy Railroad and the raw materials are brought in by rail. Kaolin is brought in from Georgia. Over three-fourths of the kaolin produced in the United States comes from a belt extending from Taylor County in western Georgia to Richmond County in the eastern part of the state extending into South Carolina. Kaolin is used in the manufacture of art ware to impart whiteness to the products being made and to give refractoriness to the products. Ball clay is also used in large amounts in the production of art ware. It is of sedimentary origin and usually more or less colored by impurities. These impurities tend to make the clay plastic and permit its moulding. Ninety-five percent of the ball clay produced in the United States comes from a belt extending from Graves County in southwestern Kentucky to Weakley, Henry, and Carrol counties in Tennessee. Feldspar is used as a component of white wares and semi-porcelain serving as a flux

binding the mass together. It is obtained from the Black Hill region of South Dakota. Quartz is used to prevent excessive shrinkage and obtained from LaSalle County, Illinois. Small amounts of special glazing material of various types are used depending on the type of ware being made. The kilns burn natural gas piped from Texas. Oil can be used as a fuel if necessary and is obtained a few miles south in the vicinity of Colmar.

THE ILLINOIS ELECTRIC PORCELAIN COMPANY

There is only one pottery in western Illinois which makes electric porcelain. It is the Illinois Electric Porcelain Company located in Macomb.

In 1884, C. W. Kettron came to Macomb from the southern part of the country. He learned his trade as a potter in Mississippi, and in Macomb he worked as a turner producing stoneware items of various shapes and sizes. In a few years Kettron went to Ohio, and worked in and observed many of the potteries located around the pottery center of the United States—East Liverpool. Here he saw a relatively new trend in the field of ceramics—the production of electric appliances. He believed that with the harnessing of electrical power, a great market for electric porcelain would arise. He returned to Macomb, dissolved his interests in the stoneware establishment, and interested the already ceramic-minded citizens of Macomb in this new and promising field of pottery. In Macomb there were the existing kilns which could be converted easily to the firing of porcelain, the large supply of semi-skilled labor and the complete lack of competition, as the nearest plant producing electric appliances was hundreds of miles distant. A few highly skilled technicians were brought to Macomb from East Liverpool to form the nucleus of the new concern. C. W. Kettron was the principal figure in the establishment of the Illinois Electric Porcelain Company in 1910, and his son, H. P. Kettron, is the president of the company today. The raw materials in the manufacture of electric porcelain are of unusually high standards. The only local material used is the Colchester clay which is utilized in making saggers. All other materials are transported from greater distances. The kaolin is an extremely fine grade imported from south England which is mined close to the English Channel. At present, no kaolin yet produced in the United States is quite equal to the English clay in the necessary qualities needed to produce electric porcelain. The ball clay is obtained in Kentucky. The feldspar is brought from the Abingdon Potteries Inc. who grind the feldspar which is mined in the Black Hills of South Dakota. The flint is ground from fine quartz obtained in Ottawa, Illinois. The glazing materials consist of ball clays, feldspar, flint, and other secret ingredients. Most plants add small, but varying amounts of talc, soda ash, silicate of soda, dextrose, etc. to accomplish correct special characteristics. The materials are brought in by the C., B. & Q. Railroad which has a spur leading to the factory door. The fuel used for firing is crude oil obtained in fields in the vicinity of Colmar.

The market for electric porcelain is country wide, and some goes to Europe, Canada, and South America. The company has sales offices throughout the United States and in Europe, and the products are marketed through their own sales organization. The finished products are transported primarily by the C., B. & Q. Railroad. However, if time is a critical factor, trucks usually handle the transportation. During the war air express was frequently used. The products were trucked to Moline and then shipped to their destination by air. Critical items in this way could reach any section of the country on the same day they were shipped from the factory.

The establishment employs 300 to 350 people all of whom come from Macomb or the adjacent country. The amount of highly skilled labor is approximately 15 percent. About 75 percent of the labor is semi-skilled. The workmen learn their trade at the plant.

The plant produces about 7,000 tons of electrical porcelain annually in the form of insulators, knobs and cleats, switch covers, and chemical porcelain such as valves and pipes of various types.

THE WESTERN STONEWARE COMPANY

Years ago, it was believed that coal could be found in the vicinity of Monmouth, the home of Western Stoneware Company. In search of coal, a clay was discovered which was of excellent grade for the manufacture of tile and brick. Because of this clay, the Monmouth Mining and Manufacturing Company was established in 1872 and began to manufacture tile and sewer pipe and a smaller quantity of brick. Twenty years later a number of men, of whom William Hannah was the principal figure, organized the Monmouth Pottery which utilized the nearby clay and produced stoneware jars, jugs, churns, etc. From these two concerns, in 1900 the Western Stoneware Company was established. It was a stock company and was fostered by the local men who had developed the two preceding clay working industries. The clays near Monmouth were still used in the beginning, but later a superior stoneware clay was found in the Pottsville formation in the vicinity of Colchester. The company leased hundreds of acres in this area and began to mine the clay and transport it to Monmouth. Today clay from the same mines is used in the production of stoneware.

The Colchester clay is brought in by rail to the factory at the rate of about a carload daily. The site of the industry is on the C., B. & Q. and the Minneapolis and St. Louis Railways. The C., B. & Q. transports the clay from the Colchester area. In 1927 the company began to make art pottery along with the stoneware products. This necessitated bringing other materials from other sections of the country. The manufacture of art pottery demanded kaolin which was obtained from Georgia, ball clay from Kentucky, flint from LaSalle County, Illinois, and feldspar from the southeast, primarily North Carolina. Both railways, but primarily the Minneapolis and St. Louis, bring in these raw materials.

Stoneware is the principal product produced and the art pottery,

though increasing, is secondary.

The fuel for the kilns is crude oil obtained from the relatively old oil fields in the vicinity of Colmar.

The markets for the finished products are country wide. The majority of the pottery reaches the market by the company's sales organization which has sales offices located in many sections. The major portion of pottery is transported by the C., B. & Q. with the Minneapolis and St. Louis Railroad handling a smaller amount. When the products are transported but a short distance, trucks often are used.

The company employs approximately 400 people of which 15 percent are skilled. The skilled labor again consists of the mould makers, designers, and decorators. The labor is all from in and around Monmouth. The skilled workmen learn their trade by experience in the factory.

The plant produces 1000 carloads of ware annually of which the majority is flower and garden ware. The company uses the trade name of "Maple Leaf" for their stoneware.

The company has also a small branch operating in Macomb which makes only terra cotta flower pots. The clay used is of local origin, and the products are made by stamping or pressing the clay into shape and then firing the ware at a low degree of temperature. The plant employs about twenty men, all of whom are from Macomb.

It is unlikely that in the relatively near future new potteries will be established in western Illinois. However, the existing potteries producing art ware and specialty products should experience a slight expansion within the next few years.

It has been mentioned that the only physical factors to attract new industries are the stoneware clays, but the existing potteries more than meet the local need. In other types of pottery, materials would have to be brought in from great distances and also the markets are relatively far. Freight rates and transportation in Western Illinois are not such that they in themselves would attract industry. The only inducement or positive factor would seem to be a comparatively large financial bonus from a specific district or town. The existing stoneware potteries of the State, excluding Western Stoneware Company, should remain about the same. The products produced are of relatively low value, and therefore the markets are restricted to a definite locality. Also the potteries should be located near the source of clay. Transportation costs are in this case a limiting factor. In the case of Western Stoneware Company they are almost fully dependent upon the florist trade, and they should experience the same trend as the art ware pottery.

It has been mentioned that art ware has experienced a great rise in production to meet the increasing domestic needs since the war. No doubt in the near future, some art ware will be imported from Europe and China. However, importations probably will never reach such relative proportions as existed before the war. The art ware potteries, however, will manufacture an increasing variety of products, and many experiments and changes will take place in art ware in an effort to keep the domestic markets. It is interesting to note that in times of depres-

sion art ware potteries are the first to suffer and usually are the hardest hit, but, on the other hand, in prosperous eras the demand for art ware increases out of proportion to other types of pottery.

Electric porcelain is related to construction and improvements in rural areas. The Rural Electrification Administration, a federal act to extend electricity in rural areas all over the country, did much to increase demands for electric porcelain. Also a great deal of porcelain is being sent to Europe and other countries engaged in reconstruction and internal development.

TEACHING OF CONSERVATION OF NATURAL RESOURCES IN ILLINOIS COLLEGES AND UNIVERSITIES

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Introduction

Statement of purpose.—The purpose of this paper is to evaluate the part that the Colleges and Universities of Illinois are doing in promoting education in the field of conservation of natural resources.

Conservation seeks to gain for society the most efficient development and wise utilization of our natural resources. In the settling and building of this nation, the people of the United States have proceeded to waste and destroy our natural endowment at an unprecedented rate; however, partially through the efforts of the conservation minded men of the nation, this onslaught has not proceeded to the point of self destruction. It is fortunate that the conservation movement began to gain power when it did so as to slightly retard the vast wasteful inroads made into the nation's resources.

Even in Colonial times there was evidence of interests in conservation, but the real significant beginnings are not noted until the latter part of the 19th century. In 1873 and again in 1890 the American Association for the Advancement of Science presented a petition to congress urging them to take action to conserve the natural resources of the nation. Probably as the result of these petitions, there was established in 1891 the Bureau of Forestry in the Department of Agriculture and the first National Forest Reserve was set aside.

Under the leadership of Theodore Roosevelt, the nation made tremendous advances in conservation of natural resources. A great landmark was the Conference of Governors that Roosevelt called in 1908. This meeting marks the beginning of 41 State Conservation Commissions.

It is true that great losses were sustained before the destructive wave was somewhat retarded. The great hordes of passenger pigeons have been swept from the skies forever and only a few remnants are left of the huge forests which once blanketed the nation. The small groups of buffalo left in the West can't even echo the glory that once was theirs as they roamed the Great Plains by the hundreds of thousands.

The objectives of conservation vary within the field. Conservation of the non-renewable resources like iron, zinc, coal and petroleum consists mainly of insuring non-wasteful mining conditions, efficient use of the product and the saving of the scrap. Renewable resources like forests and wildlife can and should be renewed by close control. Soil is a resource that can be easily damaged but need not be if proper conservational practices are employed.

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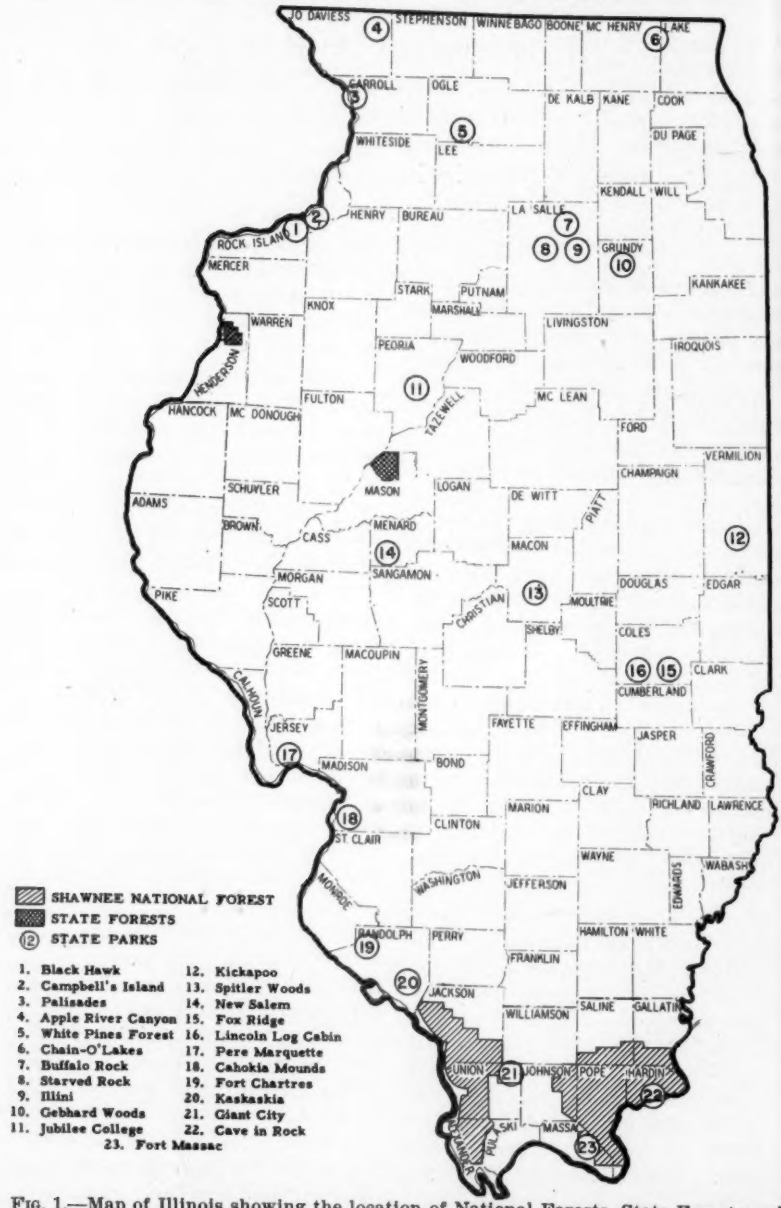

FIG. 1.—Map of Illinois showing the location of National Forests, State Forests and State Parks. (Information obtained from 1945 Official Highway Map of Illinois.)

Areas of exceptional beauty and scientific interest should be set aside for the use of all the people of the State by creating and guarding State Parks and Monuments (fig. 1).

Conservation of natural resources is a huge field of great national import, and its advancement depends upon the cooperation of everyone. But whole-hearted cooperation is impossible unless the people of the nation are aware of the conservation problems and practices.

As emphasized by all conservation organizations, private or public, for wildlife, tree, soil, or National Park conservation, the most favorable method to promote the conservation movement and to acquaint people of the problems and practices of conservation is through education. The schools of the nation provide the best media by which to spread this information; they are the educational organs of the country.

It is the privilege of every student to know the principles of conservation, the agencies trying to promote them and the results obtained through correct conservation practices. The students of today, who will be the nations leaders tomorrow, should be at least exposed to a general course in conservation of natural resources some time during their training. These leaders will have a more understanding background and will be better equipped to serve the country. They should at least know the seriousness of sediment control in streams (fig. 2), requirements and problems of the National Forests, and the type of control necessary over strategic minerals. But the leaders cannot advise or lead unless the people of the nation are themselves acquainted with the subject of conservation of natural resources.

This learning is becoming more widespread every year but it is still in its infancy. Many groups are interested in conservation and have vigorous campaigns of education, but none of these groups reach as many people as do the schools. It is true that the sportsmen of the country realized very early the problem of conservation of wildlife and have succeeded to a remarkable degree in developing wildlife conservation through private organizations and public bureaus.

It was not until 1910 when C. R. Van Hise published a volume entitled "Conservation of Natural Resources in the United States"[1] was there a popular presentation of the subject. "For the first time this all important topic was presented to the general public in such a clear and concise manner that its true significance could be grasped."[2]

Since that year only a few similar books have been written. It is true however that much has been written on the various separate phases of conservation in the last decade.

The State of Illinois has done much in the promotion of conservation of natural resources. Much was done prior to 1925 by the various branches of the State government, but it was in that year that the Department of Conservation was created and the State's efforts in conservation were unified. A brief summary of the rights, powers, and duties of the present department is as follows:[3]

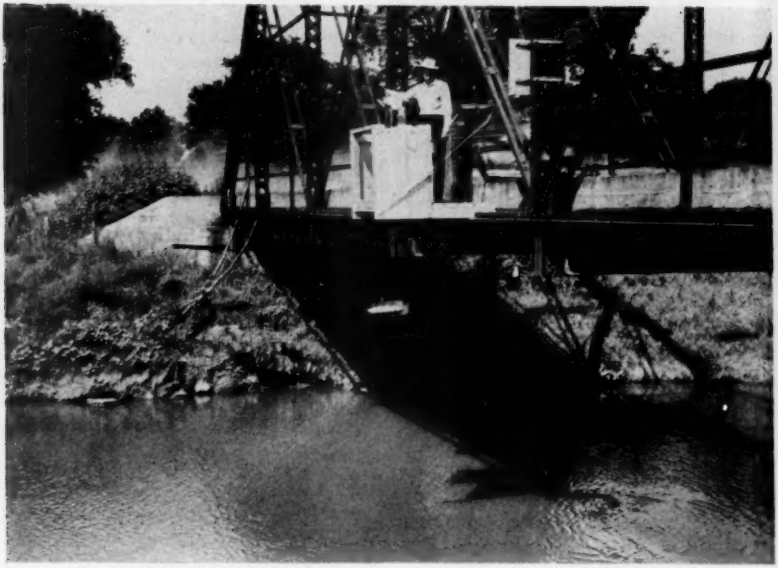

FIG. 2.—Testing the suspended sediment content of the Galena River. The study of stream transported sediment is very important in soil conservation and in deciding the efficiency of such engineering structures as dams, and irrigation ditches.

1. To administer the Fish and Game Code of Illinois.
2. To take all necessary measures for the conservation, preservation, distribution, introduction, propagation, and restoration of fishes, frogs, mussels, turtles, game, wild animals, wild fowls, birds, and forests.
3. To promote and encourage hunting, fishing, and forestry in the State.
4. To take necessary measures for the investigation and prevention of pollution of the waters of the State and to work in conjunction with other departments to this end.
5. To collect, publish, and disseminate statistics and information relating to these natural assets of the State, the activities of the Department, and the industries affected by conservation and propagation.

The Illinois Natural History Survey is another State body which is important in promoting conservation in Illinois. Its work dates back many years before the formation of its sister body, the Department of Conservation.

Another state-wide group which acts in the interest of conservation of natural resources is the Committee on Conservation of the Illinois State Academy of Science. Many conservation improvements have been brought about by the power of this group.

The Department of Conservation of the State of Illinois has had summer instruction in conservation of natural resources for several years. During the summer of 1945, in their school at Lake Villa, Illinois, two 2-week courses were given to high school students and one 2-week

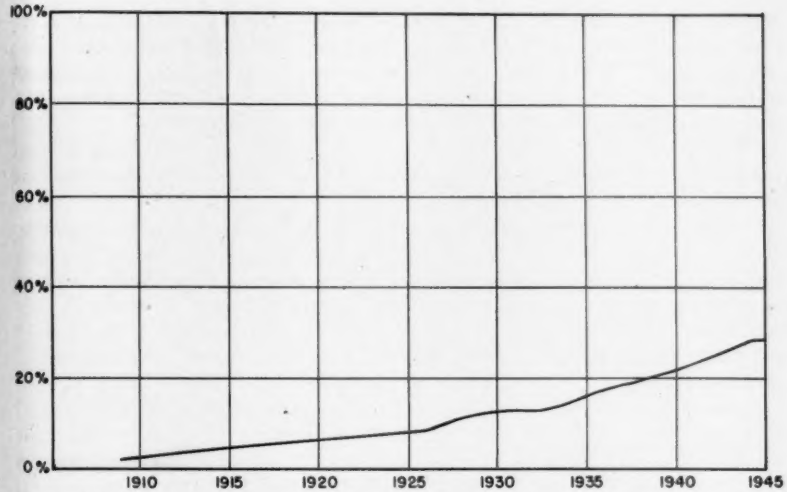

FIG. 3.—Growth of the adoption of a general course of conservation of natural resources by Illinois four-year colleges and universities.

course was given to high school teachers throughout the State.

Although this is very gratifying, this effort does not contact a large group and the courses cannot be very detailed in such a short time. The answer to the question of how to inform the people of the vital import of national and state conservation of natural resources is through the schools.

Students of college age are mature enough to grasp the gravity of conservation problems, and therefore the colleges and universities are the ideal media by which to promote conservation education. The introduction of courses dealing entirely with conservation has been tried in some Illinois high schools but as yet without much success. Perhaps the only school, or at least one of the few, offering a conservation course as such to high school students is the University High School at Carbondale, Illinois.[4]

In a recent article by V. L. Nickell,[5] Superintendent of Public Instruction in Illinois, it is revealed the State has a broad program underway to promote conservation education in the elementary and high schools of Illinois.

Survey of Illinois Colleges and Universities

According to the listing of Illinois Colleges and Universities in the 1944 Bulletin of Accredited Higher Institutions[6] as published by the United States Office of Education, there are 84 such institutions of higher learning in Illinois.

Of these listed, many are art, music, theological or aeronautical schools and are therefore not included in this survey. After excluding these types of institutions, there

remains 69 schools; 24 junior colleges and 45 four-year schools and universities. To each was sent a questionnaire requesting information about the courses offered in the field of conservation of natural resources. The following questions were asked both of the general liberal arts course in conservation and of the advanced conservation course: 1. Name of the course, 2. the date of initiation, 3. how often the course is offered, 4. the number of meetings per week, and 5. the general content and enrollment.

Returns were noted from 52 of the 69 institutions listed. In the event an institution did not return the inquiry, information concerning courses at this school was gleaned from its bulletin or register. Information gained this way probably was not as complete as that from the mailed blank.

The general course.—The most important purpose of the survey was to note the adoption of the general conservation course in the liberal arts curriculum. Such a course is defined as one of at least a semester or quarter in length and devoted entirely to the study of conservation of natural resources such as soil, water, forests, minerals, wild life, etc. This is the course which is open to all of the students and is the most important one in promoting conservation. The advanced courses are for those deeply interested in the subject; such courses do not touch a fraction of the number of students that the undergraduate general course does. It is in this elementary course that the student is introduced to the problems, practices, and importance of conservation. Also he then becomes aware that many people are in the conservation endeavor and various societies have been organized in the concern of one phase or another of conservation.

It is true that the subject of conservation of natural resources is briefly mentioned in some courses in geology, biology, geography and economics; but in such a course the matter is treated only as a side issue and its true importance is probably not emphasized. A student would have to take various courses and glean from each a small learning of conservation to attain a fair background of the subject—a background that is very necessary and that can be supplied by taking a good general course in conservation.

According to the data compiled from the returned questionnaires, the earliest any such general conservation course was taught in an Illinois college or university was in 1909 at the University of Chicago. Some state teachers colleges also adopted it quite early. It is revealed that 13 schools or 28 percent of the four-year colleges and universities included in the survey actually have a general conservation course in this curriculum (table 1). None of the junior colleges reported offer such a course; if a computation were made including the junior colleges, the percentage of institutions of higher learning in Illinois offering a course in conservation of natural resources would be 18 percent. An alarmingly low figure! Even if the junior colleges are excluded, the figure of 28 percent is still very low.

The survey reveals that most of the schools have not yet realized the importance of the subject and there-

FIG. 4.—Lower dell of Mattheissen State Park Nature Area in LaSalle County near Oglesby. The State has set this area aside as a nature preserve and wildlife sanctuary where the plant and animal life of Illinois may be saved for all time.

fore have not initiated such a general course. But such a nationally important topic, which is becoming increasingly more important as time goes on and which was brought before the public in many ways during the war, cannot be ignored. More schools are adopting such a course every year. The growth of the adoption of a general course of conservation of natural resources by Illinois four-year colleges and universities is given in figure 3. The youth of today must be informed of the importance and necessity of conserving our natural resources or the citizens of tomorrow will live in a depleted world. Future generations should not be forced to live in a world almost void of natural resources because the present citizens are ignorant of conservation problems.

The fact that almost all colleges formally listed as "Teachers Colleges" have adopted the general course is very encouraging. Future teachers with the advantage of having had such a course in conservation, will be likely to urge the adoption of such a course into the curriculum of the school at which they may later teach. In addition to being offered in the regular curriculum, it may be stated that the general course is also offered in the summer session and as an extension course at one or two of the schools.

According to census of opinion, twelve of the thirteen schools offering the general course have placed it

TABLE 1.—ACCREDITED HIGHER INSTITUTIONS IN ILLINOIS OFFERING COURSES IN CONSERVATON OF NATURAL RESOURCES (1945)

School	Offers a general course	When initiated	Offers advanced work
University of Chicago, Chicago	x	1909	x
Illinois State Normal University, Normal	x	1914	x
Northern Illinois State Teachers College, DeKalb	x	1920	
Northwestern University, Evanston	x	1927	x
Western Illinois State Teachers College, Macomb	x	1928	
The Principia College, Elsah	x	1933	
Eastern Illinois State Teachers College, Charleston	x	1935	
Southern Illinois Normal University, Carbondale	x	1936	x
Rosary College, River Forest	x	1938	
Augustana College, Rock Island	x	1940	
Concordia Teachers College, River Forest	x	1943	
McKendree College, Lebanon	x	1943	x
Chicago Teachers College, Chicago	x	1944	
University of Illinois, Urbana			x

under the supervision of the department of geography or its equivalent.

The advanced courses.—Advanced courses in conservation are here defined as those which devote all their time to only one phase of conservation and cover it quite thoroughly in a semester or two. These courses are to be generally found only in the larger universities and are attended by students seriously interested in soil, forest, wildlife, etc., conservation and probably plan to make it, directly or indirectly, their livelihood. These courses generally have certain prerequisites which keep the subject from the undergraduate student body.

Six schools gave indication that the study of conservation of natural resources is carried beyond the general course. The University of Illinois, one of the largest schools in the nation, offers advanced training in soil conservation in the Agricultural School; a course in forestry is offered in the Liberal Arts School; and a general study of the conservation of wildlife is listed but is open to only advanced zoology students. As far as known, the only course in "Methods and Problems in Conservation" offered in an Illinois school is the one scheduled at Southern Illinois Normal University at Carbondale.

Another factor to consider when discussing a school course is the student attendance. Most of the colleges list 20 to 30 as the approximate pre-war size of the general conservation classes; the universities list slightly larger classes. These figures are perhaps average for elective courses in the various schools, maybe slightly below average. The only way to influence more students is to make the course a required one. It should not be listed as fulfilling the science requirement nor should it be placed as a substitute for another subject. Need it be listed as a substitute for anything? Surely a subject so important as the future of a nation and

how to insure it should rank high on the list of subjects "required to know" or subjects needed for a liberal education.

If the upward trend toward conservation through education continues, and surely it will, more educators will awaken to its importance and in the end perhaps require that at least a general course in conservation of natural resources be taken by every student.

Illinois, with its tremendous wealth of natural resources (fig. 4) and its wonderful colleges and universities, should be one of the leading states in education of conservation of natural resources. The students of the nation should be taught the importance of conservation of natural resources by being required to take at least a general course during their college days. It is the educators duty to see that the youth is informed of the importance of conservation to insure our national heritage for future generations.

Conclusions

1. Twenty-eight percent of the four-year colleges and universities of Illinois offer the student a chance to become aware of the importance of conservation by offering a general course in conservation of natural resources.

2. As far as known, no junior college in Illinois offers such a course.

3. Six Illinois schools offer advanced work in conservation of natural resources.

Acknowledgment

The author wishes to express his appreciation to all the persons who took time from their busy schedules to submit data concerning conservation courses at their respective schools. Figure 2 is reproduced through the courtesy of the Rock Island Office of the United States Army Engineers, and 4 through the courtesy of the Illinois Department of Conservation. The drafting was done by Mr. Nelson and Mr. Engeland.

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LAKE MICHIGAN PORTS: A CLASSIFICATION BY ITEMS OF TRAFFIC

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Because ports are transfer points between two methods of transportation, the materials which are handled by a port can be indicative of the activities of a port city and its hinterland. For example, the iron ore shipped from Escanaba reveals the great mining activities nearby. Also, the variety of items which flow through a port can indicate the value of the waterside position to the economy of the port city. That these statements are true would hardly be denied, yet literature is lacking in methods of indicating the functional value of a port to its port city and hinterland.[1] As a step in this direction, this paper presents quantitative criteria for the classification of ports by items of traffic, and a classification of Lake Michigan ports based on that method. It is hoped that later studies may expand this idea and a contribution to the methodology of geography will result.

Method

The criteria for classification are derived from a study of the port statistics published yearly by the War Department.[2] To facilitate comparisons, the data for the principal items of traffic were reduced to percentages of the total traffic of the port and these percentages form the basis for the classification (table 1). Many of the ports can be classified easily on this basis, but borderline cases exist, especially among the larger ports which tend to have a greater variety of traffic than do smaller ports. However, large volume is no indication of great variety; the fifth largest port in volume of tonnage has 94 percent of its traffic confined to one item.

In reducing the principal items of traffic to percentages of the total traffic, items of like origin or related use such as sand, stone, and gravel, or gasoline and fuel oils created a problem. In order to classify a port in a category representative of its traffic, these items of like origin or related use have been combined and treated as one item. Another problem has been the variety of items carried on the cars in car ferries. In all instances, the variety has been wide, and as the car ferries are essentially extensions of rail lines and no indication of the destination of the cars can be obtained from the statistics, a category of car ferry ports has been established to obviate classifying ports as General ports when they are merely shipping and receiving points for loaded cars.

[1] Several authors have discussed the value of ports to cities and the relation of ports to hinterlands, but have not attempted to evaluate, by quantitative measurements, the classification of ports. See especially E. Van Cleef, Trade Centers and Trade Routes: D. Appleton-Century Co., Inc., New York, 1937, pp. 106-138; W. D. Jones and D. S. Whittlesey, An Introduction to Economic Geography: University of Chicago Press, Chicago, 1925, pp. 347-358; J. R. Smith and M. O. Phillips, Industrial and Commercial Geography: Henry Holt and Company, New York, 3rd ed., 1946, pp. 755-780.

[2] U. S. War Department, Annual Report of the Chief of Engineers: Government Printing Office, Washington, annual.

TABLE 1.—CRITERIA OF CLASSIFICATION

Specialty ports (S): Ports with more than 80 percent of traffic confined to one item, and no other item constituting 5 percent of the total traffic.
Subtype (r): Receiving port.
Subtype (s): Shipping port.
Combination ports (C): Ports at which not more than three items, each of which is at least 10 percent of the total, constitute 80 percent or more of the traffic.
General ports (G): Ports at which no three items constitute as much as 80 percent of the total traffic.

CLASSIFICATION

In the classification, three principal types of ports have been recognized and each type has been designated by a letter (table 1). The two subtypes are applicable only to the Specialty ports, indicating the port's function as a shipping or receiving port.

Specialty ports.—Specialty ports are the most numerous type, comprising 57 percent of the total ports on the lake (figure 1). In view of the different functions of shipping and receiving ports to the port city and hinterland, subtypes have been adopted according to whether a port receives or ships the specialty item. Car Ferry ports are excluded from the subtype classification because of the cross-haul nature of their traffic.

There are six different items of traffic which are handled by specialty ports. Coal, the item found most frequently in port statistics of Lake Michigan cities, accounts for classification of nine ports as Specialty Receiving ports (St. Ignace, Sister Bay, Two Rivers, Suttons Bay, Algoma, DePere, Port Washington, Racine and Sheboygan). Since the cost of trans-shipping coal inland from the lake shore raises the cost prohibitively as a source of heat and power, further study of the activities of these port cities will probably indicate a special industry based on the use of power. This is known to be true in at least one city, Port Washington, which has a large steam-electric generating station based on imported coal.

The second most important in number are the fishing ports, all of which are small in tonnage handled. Six ports have their entire traffic confined to the receipt of fish (Big Saumico, Michigan City, Oconto, Pensaukee, Saugetuck, and Whitehall). Car ferry ports are third most important in the number of ports classified as Specialty ports (Frankfort, Kewaunee, Ludington, Mackinaw City, and Manistique). They are both shipping and receiving ports, as befits the type of traffic they handle.

Stone ports are the fourth most important of the Specialty ports, with four devoted to shipping of the item (Buffington Harbor, Grand Haven, Port Inland, and Portage Lake). Two fresh fruit receiving ports (Leland and Northport) and one iron ore shipping port (Escanaba) make up the remainder of the specialty classification.

Combination ports.—In Combination ports the items of traffic are diverse, and yet the variety of items shipped or received at any one port indicates a concentration either in a few types of activities at the port city or the relative unimportance of waterside location to the city in the shipping and receiving of its products. It was not found practical to use the sub-classifications of shipping

and receiving ports in this category because the items of traffic in some cases were both received and shipped.

Fuels ports, handling coal and petroleum products, are the most numerous of the Combination ports, with four examples (Charlevoix, Gladstone, Holland, and Traverse City) followed closely by coal and stone ports with three examples (Kenosha, South Haven, and Manistee). Only two other ports of this classification handle the same types of items—Menominee and Manitowoc are both classified as car ferry, stone and coal ports. The other six ports classed as Combination ports are individual in the combination of items handled: iron ore, stone and coal (Gary); car ferry, coal, and petroleum products (Milwaukee); stone, coal, and petroleum products (St. Joseph); car ferry, stone, and petroleum products (Sturgeon Bay); iron ore, coal, and petroleum products (Indiana Harbor); and coal and steel billets (Waukegan).

General ports.—The five remaining ports on Lake Michigan for

which data are available are General ports (Chicago-Calumet, Green Bay, Petosky, St. James, and Muskegon). Each has a high percentage of its traffic confined to a few items, but a wide variety makes up the remainder of their traffic. Two of these ports (St. James and Petosky) are small in total tonnage handled, and it is felt that both of these would be in a more specialized classification if more detailed statistics on them were available. The other three ports are truly General ports, receiving and shipping a wide variety of goods.

Distribution of Ports

The map of Lake Michigan ports shows that few ports are closer than ten miles apart and that there are few stretches of shore line of more than fifty miles without a port. Around the lake from St. Ignace to Mackinaw City the midpoint in the number of ports is reached between Chicago and Waukegan. The line dividing the ports on the northern half of the lake from those on the southern half crosses the lake from north of Kewaunee on the western shore to south of Portage Lake on the eastern side.

General ports are more or less evenly spaced around the lake. They are located at the head of Green Bay, the south end of Lake Michigan, in the middle and at the north end of the eastern shore, and on Beaver Island—situations, except for the last named, from which they serve a wide hinterland. The position of Milwaukee between the general ports of Chicago and Green Bay, with their overlapping hinterlands, helps to explain the puzzling lack of variety in its items of trade.

In contrast to the even distribution of the General ports is the concentration of the Specialty and Combination ports. Of the twenty-four ports which are located in the northern part of the lake, exactly two-thirds are Specialty ports. This is 9 percent more than the average for the lake as a whole. Among these northern Specialty ports are the two fruit ports, the iron ore port, four of the six fishing ports, five of the nine coal ports, two of the five car ferry ports, and one of the four stone ports.

Whereas the Specialty ports are concentrated on the northern part of the lake, a similar concentration of Combination ports is apparent in the southern part of the lake. Here are located two-thirds of the ports so classified. None of the ten Combination ports in the southern part of the lake has the same combination of items of trade, whereas three of the five ports classified in this category in the northern part of the lake are fuel ports—indicative, perhaps, of the broader economic base of the southern port cities or of larger hinterlands served by them.

Conclusions

The classification of ports on the basis of the number of items of trade into Specialty, Combination, and General ports presents a basis for the investigation and comparison of port cities and their hinterlands. It is not felt that this method should be an end product in itself, nor that the entire picture of a port's function can be obtained by this classification. However, the method recommends itself, by directing attention through the items of traffic, to activities of the port city or its hinterland.

GEOLOGY

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1. Structural Trends in the Pecatonica Quadrangle Based upon Decorah Stratigraphy: CHARLES L. BIEBER, North Central College, Naperville. (slides)

2. Some Chester Outcrops and Subsurface Sections in Southeastern Illinois: ELWOOD ATHERTON, Illinois State Geological Survey, Urbana. (slides)

* 3. Correlation Problems of the "Benoist" Sand and Bethel Formation in Southern Illinois: DAVID H. SWANN, Illinois State Geological Survey, Urbana. (slides)

* 4. Oil Well Spacing in Illinois During World War II: ALFRED H. BELL, Illinois State Geological Survey, Urbana. (slides)

* 5. Moore's Method: One Empirical Approach to the Interpretation of Resistivity Data: M. B. BUHLE, Illinois State Geological Survey, Urbana. (slides)

* 6. Plant Microfossils from Clay Deposits in Union County, Illinois: R. M. KOSANKE, Illinois State Geological Survey, Urbana. (slides)

* 7. Geological Conditions that may Cause Coal Mining Fatalities: ROLF W. ROLEY, Illinois State Geological Survey, Urbana. (slides)

8. Unusual Oolite Grains from the Ste. Genevieve Limestone: RAYMOND S. SHRODE, Illinois State Geological Survey, Urbana. (slides)

* 9. Observations on Temperature of Formation of Illinois Fluorite: R. M. GROGAN, Illinois State Geological Survey, Urbana. (slides)

*10. A Study of the Refractive Indices of Opaque Isometric Minerals: M. DARWIN QUIGLEY, Northwestern University, Evanston. (slides)

11. A Spectrographic Check on the Petrographic Method: CARLETON A. CHAPMAN and GEO. K. SCHWEITZER, University of Illinois, Urbana. (slides)

*12. Geological Applications of the Ionic Potential: GEO. K. SCHWEITZER and CARLETON A. CHAPMAN, University of Illinois, Urbana. (slides)

*13. A Summary of Philippine Geology: H. L. PATTON, University of Illinois, Urbana.

*14. A Rockslide in the Snake River Range, Wyoming: WILLIAM A. OESTERLING, University of Illinois, Urbana. (slides)

*15. The Distribution of Zircons in the Tuscaloosa Formation of North Carolina: WALTER R. ZIEBELL, University of Illinois, Urbana. (slides)

*16. A Treatment of the Effects of Hole Caving upon Resistivity Curves of Electric Logs: WILLIAM E. MCCOMMONS, University of Illinois, Urbana (Read by title.)

*Not published.

SOME CHESTER OUTCROP AND SUBSURFACE SECTIONS IN SOUTHEASTERN ILLINOIS[1]

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Introduction

This paper is intended to aid studies of the Chester series by presenting electric logs of several formations alongside the descriptions of corresponding cores or outcrops, and, for the basal Chester, insoluble residue zones. For the electric logs, lithologic interpretations are shown in the central columns. For the cores and outcrops, the rocks are described in some detail. Fine dashed lines extending from the electric log to the graphic log are meant to draw attention to the similarities of succession. The locations of all wells, outcrops, and cores are shown on the index map of southeastern Illinois (fig. 1). The Chester formations illustrated include the Kinkaid, Degonia, Clore, Palestine, Menard, Golconda, and Renault (Downeys

[1] Published with permission of the Chief, Illinois State Geological Survey, Urbana, Illinois.

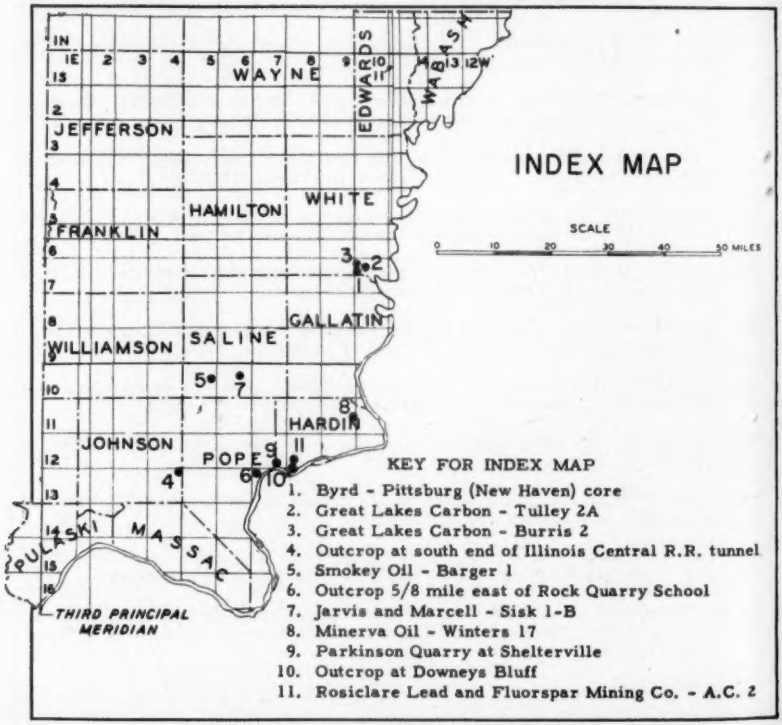

FIG. 1.—Locations of cores and outcrops

FIG. 2.—Kinkaid formation

Bluff and Shetlerville) formations.

KINKAID FORMATION (FIG. 2)

The Kinkaid formation in the "New Haven" core (drilled in 1913 and described by Savage[2]) is shown graphically with the corresponding portion of the electric log of a well about 3/8 mile to the northeast.

The Kinkaid in the core is immediately overlain by Pennsylvanian sandstone and conglomerate and is underlain by the Degonia shown in fig. 3. Outstanding features of the Kinkaid in both core and electric log are the massive upper and lower limestones. The intervening portion includes some limestone in its central and sandstone in its lower part. At the base are a few feet of green, red, and purple shales.

DEGONIA FORMATION (FIG. 3)

The "New Haven" core and electric logs of nearby wells show three sandstone beds within 100 feet below the Kinkaid formation. Oil geologists in this area generally put the upper two beds in the Degonia formation, and the third bed in the Clore formation, as is done here. It is possible that when the Degonia formation is traced in detail from the type locality in western Illinois across to this area, the bounds shown here may be modified.

CLORE FORMATION (FIG. 3)

The Clore formation in this area consists mainly of shale, shaly limestone, and sandstone. The prominent sandstone in the upper part is known to oil geologists as the "Clore sand." Commonly more green shale is encountered than is reported from the "New Haven" core.

PALESTINE FORMATION (FIG. 4)

The Palestine formation in the "New Haven" core is 105 feet thick and consists of sandstone except for about 5 feet of shale and shaly sandstone near the top, and minor shale laminae. The Palestine formation in southeastern Illinois generally is thinner than this, averaging about 55 feet, and it usually includes a larger proportion of shale.

MENARD FORMATION (FIGS. 4 AND 5)

There is an unconformity below the Palestine formation, and in many parts of southeastern Illinois the Menard includes higher beds than are present in the "New Haven" core (fig. 4). The "massive Menard" occurs between the depths 2170′6″ and 2205′ in the core, and the "little Menard" between 2214′9″ and 2219′9″. The "little Menard" is often sandy in this part of the state.

Few electric logs are available near the Menard outcrop described by L. E. Workman[3] and shown in fig. 5. The formation is sufficiently uniform, however, for the electric log of the Smokey Oil-Barger No. 1 well, about 18 miles northeast of the outcrop, to show considerable similarity. Neither the upper nor the basal portions of the formation are exposed in the outcrop. The top of the "massive Menard" is at 63′11″ in the outcrop. In the well the Menard is underlain by shaly sandstone of the Waltersburg formation.

Separation of the basal Menard shale from underlying Waltersburg shale is usually difficult. Some geologists prefer to mark the base of the Menard formation by the base of the "little Menard" limestone.

GOLCONDA FORMATION (FIG. 6)

The Golconda formation in south-

[2] Technical files, State Geological Survey, Urbana, Illinois.

[3] Field notes. L. E. Workman. State Geological Survey, Urbana, Illinois.

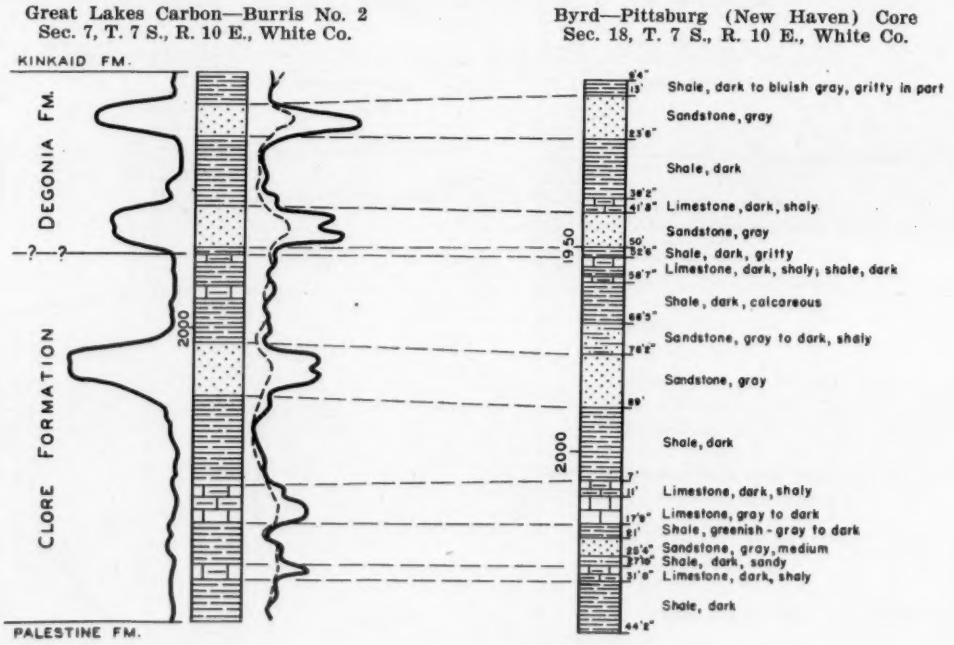

FIG. 3.—Degonia and Clore formations

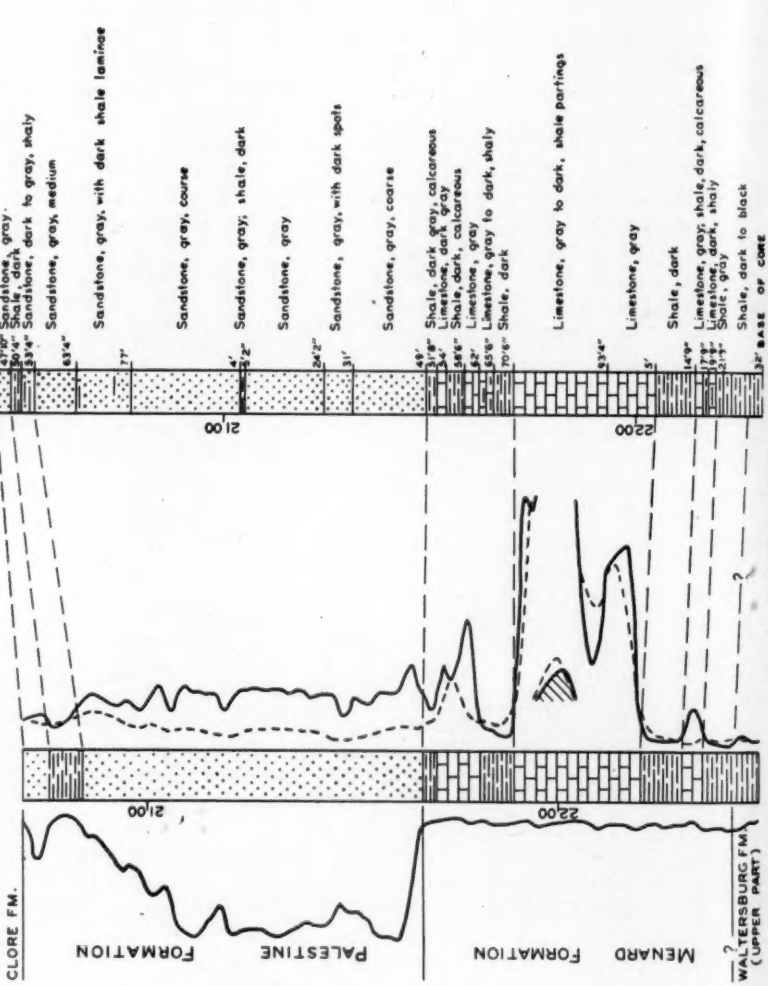

FIG. 4.—Palestine and Menard formations

Fig. 4.—Palestine and Menard formations

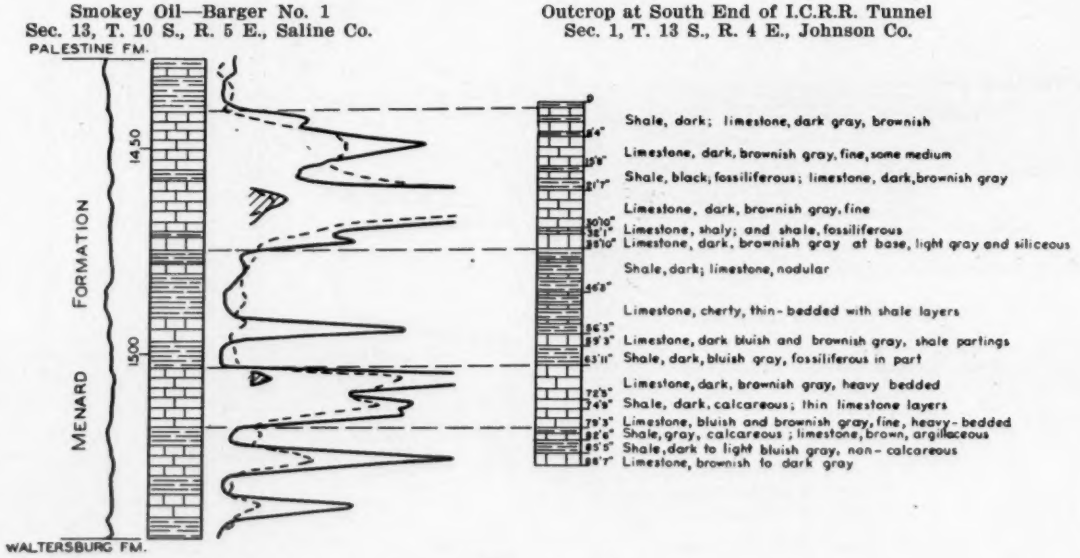
Smokey Oil—Barger No. 1
Sec. 13, T. 10 S., R. 5 E., Saline Co.
Outcrop at South End of I.C.R.R. Tunnel
Sec. 1, T. 13 S., R. 4 E., Johnson Co.
PALESTINE FM.
MENARD FORMATION
WALTERSBURG FM.
14.50
1500
Shale, dark; limestone, dark gray, brownish
Limestone, dark, brownish gray, fine, some medium
Shale, black, fossiliferous; limestone, dark, brownish gray
Limestone, dark, brownish gray, fine
Limestone, shaly; and shale, fossiliferous
Limestone, dark, brownish gray at base, light gray and siliceous
Shale, dark; limestone, nodular
Limestone, cherty, thin-bedded with shale layers
Limestone, dark bluish and brownish gray, shale partings
Shale, dark, bluish gray, fossiliferous in part
Limestone, dark, brownish gray, heavy bedded
Shale, dark, calcareous; thin limestone layers
Limestone, bluish and brownish gray, fine, heavy-bedded
Shale, gray, calcareous; limestone, brown, argillaceous
Shale, dark to light bluish gray, non-calcareous
Limestone, brownish to dark gray

Fig. 5.—Menard formation

Outcrop Near Rock Quarry School
Sec. 5, T. 13 S., R. 7 E., Pope Co.
Jarvis Bros. and Marcell—Sisk No. 1-B
Sec. 15, T. 10 S., R. 6 E., Saline Co.
Hardinsburg sandstone
Covered with slumped blocks of sandstone
Shale, dark gray, non-calcareous
Shale, dark gray, calcareous
Limestone, gray, fine to coarse
Covered, probably considerable limestone
Shaly limestone, calcareous shale, dark gray, brown
Limestone, gray, coarse
Shale, brown, calcareous, fossiliferous
Covered
Shale, dark gray, very calcareous, non-fossiliferous
Shale and shaly limestone
Limestone, yellowish gray, fine above, coarse below
Limestone, brown, coarse, fossiliferous
Covered, probably shaly limestone
Limestone, brown, fine, fossiliferous
Shale, gray, greenish and brown, sandy, non-fossiliferous
Covered, probably shale
Shale, dark gray, calcareous, very fossiliferous
Shaly limestone and shale, interlaminated
Limestone, gray, coarse
Shale, gray and brown, thinly laminated, weak, micaceous, gritty
1800
1900
HARDINSBURG FM. (LOWER PART)
FORMATION
GOLCONDA

FIG. 6.—Golconda formation

eastern Illinois typically includes at the top dark gray, red, and green shales with thin, brown, sublithographic dolomite. The bulk of the formation consists of a zone which is dominantly limestone, underlain by a zone which is dominantly shale. At the base is the "Barlow limestone," with sometimes a few feet of basal shale. The "Barlow" is a thin extensive bed, often mapped to show subsurface structure. In the sections illustrated, most of the upper shale zone was eroded before deposition of the Hardinsburg formation. The "Barlow limestone" is shown in the electric log at the base of the Golconda. Samples show that in this well the "Barlow" is immediately underlain by dark gray silty shale and sandstone of the Cypress formation. The lower part of the Golconda is not exposed in the outcrop section described by L. E. Workman.[3]

The electric log is from a well located about 17 miles north of the outcrop.

FIG. 6.—Golconda formation

RENAULT (DOWNEYS BLUFF AND SHETLERVILLE) FORMATION

(FIGS. 7 AND 8)

The lower part of the Chester in Hardin County has been called the Renault formation. Frank Tippie[4] correlates the upper part of the Renault with the basal Paint Creek of western Illinois, and has proposed the name "Downeys Bluff" for this member of the Paint Creek, based on the type section shown in fig. 8 and located at Downeys Bluff in NW¼, SE¼, sec. 5, T. 13 S., R. 8 E. The remainder of the Renault is here referred to as the Shetlerville member.[5]

The Downeys Bluff and Shetlerville are illustrated by an electric log (fig. 7), the outcrop section at Shetlerville[6] (fig. 7), Tippie's type section for the Downeys Bluff[4] (fig. 8), and the core[6] (fig. 8) from which he describes insoluble residue zones of the Renault formation.[7] Tippie subdivides the Renault into five zones, A to E, based on insoluble residues. These zones are shown for the core and approximated for the electric log and two outcrop sections.

In the electric log (fig. 7) it is impracticable to pick the contact of the Shetlerville on the underlying Levias member of the Ste. Genevieve formation, so the position of this contact is estimated. In the Parkinson quarry section (fig. 7), the sublithographic limestone at 15 to 18.5 feet is correlated with the sublithographic limestone at depth 223.8 feet in the core (fig. 8), and therefore is placed in the C zone of the Shetlerville formation.

ACKNOWLEDGMENTS

Mr. A. H. Cronk, Superintendent, Rosiclare Lead and Fluorspar Mining Company, Rosiclare, Illinois, has given permission to describe the lithology of part of the core from the Rosiclare Lead and Fluorspar Mining Company—A. C. No. 2 diamond drill hole. Thanks are extended to various members of the Illinois State Geological Survey for their help.

[3] Field notes. L. E. Workman. State Geological Survey, Urbana, Illinois.

[4] F. E. Tippie, Subsurface Stratigraphy of Lower Chester Formations in Parts of Illinois and Western Kentucky. Ill. State Geol. Survey, unpublished manuscript.

[5] cf. Lexicon of Geologic Names of the U. S., U. S. G. S. Bull. 896, p. 1985.

[6] Described by F. E. Tippie, Technical files, State Geological Survey, Urbana, Ill.

[7] F. E. Tippie, Insoluble Residues of the Levias and Renault Formations in Hardin County, Illinois: Trans., Illinois State Acad. Sci., Vol. 36, No. 2, December 1943, p. 155.

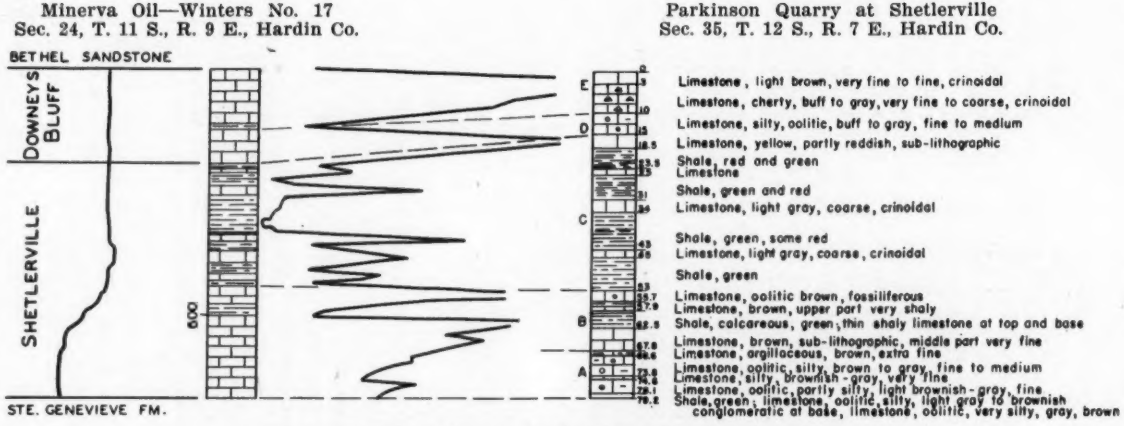
Minerva Oil—Winters No. 17
Sec. 24, T. 11 S., R. 9 E., Hardin Co.
Parkinson Quarry at Shetlerville
Sec. 35, T. 12 S., R. 7 E., Hardin Co.
BETHEL SANDSTONE
DOWNEYS BLUFF
SHETLERVILLE
STE. GENEVIEVE FM.
E
D
C
B
A
Limestone, light brown, very fine to fine, crinoidal
Limestone, cherty, buff to gray, very fine to coarse, crinoidal
Limestone, silty, oolitic, buff to gray, fine to medium
Limestone, yellow, partly reddish, sub-lithographic
Shale, red and green
Limestone
Shale, green and red
Limestone, light gray, coarse, crinoidal
Shale, green, some red
Limestone, light gray, coarse, crinoidal
Shale, green
Limestone, oolitic brown, fossiliferous
Limestone, brown, upper part very shaly
Shale, calcareous, green, thin shaly limestone at top and base
Limestone, brown, sub-lithographic, middle part very fine
Limestone, argillaceous, brown, extra fine
Limestone, oolitic, silty, brown to gray, fine to medium
Limestone, silty, brownish-gray, very fine
Limestone, oolitic, partly silty, light brownish-gray, fine
Shale, green; limestone, oolitic, silty, light gray to brownish
conglomeratic at base, limestone, oolitic, very silty, gray, brown

FIG. 7.—Renault (Downeys Bluff and Shetlerville) formation

Downeys Bluff Section
Sec. 5, T. 13 S., R. 8 E., Hardin Co.

Rosiclare Lead and Fluorspar Mng.—A. C.
No. 2 Core
Sec. 32, T. 12 S., R. 8 E., Hardin Co.

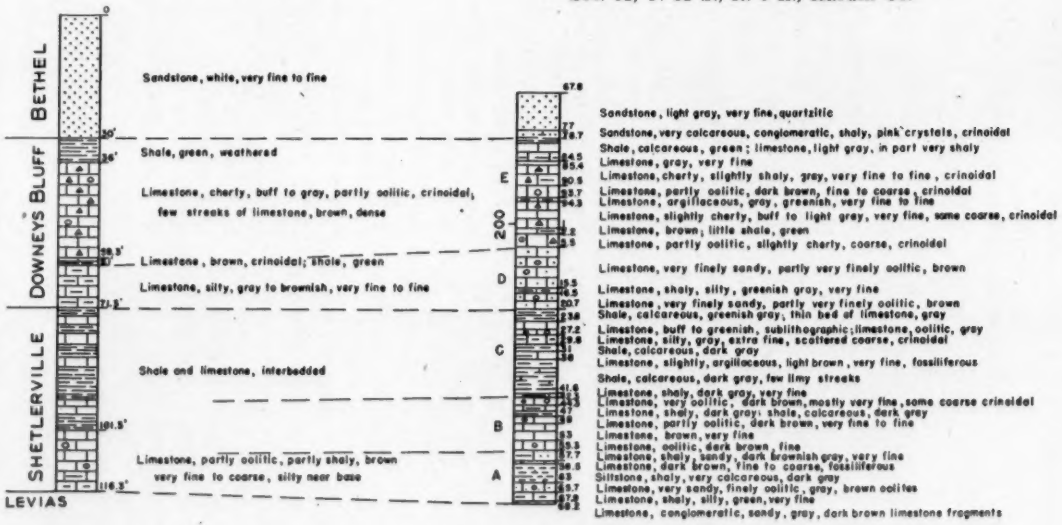
BETHEL
DOWNEYS BLUFF
SHETLERVILLE
LEVIAS
0
20'
26'
71.5'
191.5'
116.5'
Sandstone, white, very fine to fine
Shale, green, weathered
Limestone, cherty, buff to gray, partly oolitic, crinoidal; few streaks of limestone, brown, dense
Limestone, brown, crinoidal; shale, green
Limestone, silty, gray to brownish, very fine to fine
Shale and limestone, interbedded
Limestone, partly oolitic, partly shaly, brown very fine to coarse, silty near base
200
E
D
C
B
A
67.8
77
78.7
84.5
85.4
90.6
93.7
94.3
98.2
99.5
105.5
106.5
107.7
138
172
175.6
181
187
189
193
195.5
197.7
198.5
199
205.7
207.4
213.1
Sandstone, light gray, very fine, quartzitic
Sandstone, very calcareous, conglomeratic, shaly, pink crystals, crinoidal
Shale, calcareous, green; limestone, light gray, in part very shaly
Limestone, gray, very fine
Limestone, cherty, slightly shaly, gray, very fine to fine, crinoidal
Limestone, partly oolitic, dark brown, fine to coarse, crinoidal
Limestone, argillaceous, gray, greenish, very fine to fine
Limestone, slightly cherty, buff to light gray, very fine, some coarse, crinoidal
Limestone, brown, little shale, green
Limestone, partly oolitic, slightly cherty, coarse, crinoidal
Limestone, very finely sandy, partly very finely oolitic, brown
Limestone, shaly, silty, greenish gray, very fine
Limestone, very finely sandy, partly very finely oolitic, brown
Shale, calcareous, greenish gray; thin bed of limestone, gray
Limestone, buff to greenish, sublithographic; limestone, oolitic, gray
Limestone, silty, gray, extra fine, scattered coarse, crinoidal
Shale, calcareous, dark gray
Limestone, slightly, argillaceous, light brown, very fine, fossiliferous
Shale, calcareous, dark gray, few limy streaks
Limestone, shaly, dark gray, very fine
Limestone, very oolitic, dark brown, mostly very fine, some coarse crinoidal
Limestone, shaly, dark gray; shale, calcareous, dark gray
Limestone, partly oolitic, dark brown, very fine to fine
Limestone, brown, very fine
Limestone, oolitic, dark brown, fine
Limestone, shaly, sandy, dark brownish gray, very fine
Limestone, dark brown, fine to coarse, fossiliferous
Siltstone, shaly, very calcareous, dark gray
Limestone, very sandy, finely oolitic, gray, brown oolites
Limestone, shaly, silty, green, very fine
Limestone, conglomeratic, sandy, gray, dark brown limestone fragments

FIG. 8.—Renault (Downeys Bluff and Shelterville) formation

STRUCTURAL TRENDS IN THE PECATONICA QUADRANGLE BASED UPON DECORAH STRATIGRAPHY

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North Central College, Naperville

The Pecatonica quadrangle in northern Illinois is located on the southern flanks of the Wisconsin arch. Rock exposures are plentiful in the north half of the area where the glacial drift cover is thin. Southeastward the drift thickens and bedrock exposures are less numerous. The stratigraphic formation upon which this report is based, and upon which the structural trend map is drawn, is the relatively thin transition zone between the Platteville and Galena formations, interpreted herein as Decorah.

Rocks of Decorah age average from 10 to 20 feet thick over the crest of the Wisconsin arch in the Pecatonica quadrangle. The formation comprises thin to medium-bedded fossiliferous dolomites, interspersed sparingly with blue-green shaly partings. The lower Decorah beds consist of a greenish-blue shaly facies which is distinctive when exposed on fresh surfaces. Locally the shaly phase is absent.[1] *Sowerbyella* is commonly present in the lower Decorah beds. Zones crowded with *Dalmanella* are scattered throughout the Decorah,[2] but tend to be more plentiful upward. Ramose bryozoans are concentrated locally with the *Dalmanella* zones.

Lithologically, the upper beds of the Decorah grade into the buff-colored sugary and commonly cherty Galena (Prosser member). The Decorah-Galena contact cannot be drawn with certainty, but herein is taken to be where crowded *Dalmanella* zones cease and green shaly partings give way to the typical Galena lithology. Dwarf forms of *Receptaculites* are scattered in the transitional upper Decorah horizon.

The contact between Platteville and Decorah beds is drawn at the base of the blue-green shaly dolomite. The Spechts Ferry member of the Platteville formation is not surely recognized in the area, but may be included in the dense, buff, locally cherty beds which commonly underlie the Decorah. The Spechts Ferry member is reported in south central Wiconsin.[3] The number three and four beds of the Harrison section may represent the Spechts Ferry member. At a roadside exposure in the north part of the quadrangle in the SW.¼ SW.¼ sec. 36, T. 29 N., R. 9 E., *Pionodema subaequata* is in shaly dolomite underlying Decorah beds. In the west part of the area, upper Platteville rocks near the Decorah contact exhibit buff to brown shaly partings on wavy bedding planes.

[1] DuBois, E. P., Subsurface relations of the Maquoketa and "Trenton" formations in Illinois: Illinois Geol. Survey Rept. Inv. 105, pp. 21-23, 1945.

[2] Bays, C. A. and Raasch, G. O., Mohawkian relations in Wisconsin: Guidebook of the 9th. Ann. Field Conference Kansas Geol. Soc., p. 298, 1935.

[3] Bays, C. A. and Raasch, G. O., op. cit.

ROADSIDE QUARRY, THREE MILES SOUTHEAST OF HARRISON, CENTER OF SEC 36, T. 28 N., R. 11 E., ROCKFORD QUADRANGLE

	Covered.	Thickness Ft.	In.
10.	Dolomite, buff, massive, cherty, sugary, weathered	6	
9.	Dolomite, buff, a few green shaly partings, weathers sugary; *Dalmanella*, bryozoans, fucoids	10	
8.	Dolomite, gray, blue-green shaly partings common, beds 2 to 10 inches thick; fucoids profuse on the bedding planes below		8
7.	Dolomite, buff, massive, a few shaly partings at top, iron stains, sparingly fossiliferous	1	6
6.	Dolomite, thin-bedded, a few blue-green shaly partings, *Dalmanella* sparing	0	8
5.	Dolomite, buff to blue, blue wavy shaly partings, fossiliferous	0	7
4.	Dolomite, buff, thin-bedded, brown shaly partings; siliceous, rotting, weathers white; fossiliferous in center with *Sowerbyella* and *Holopea*	2	2
3.	Dolomite, buff, chert common, beds 2 to 6 inches thick; a few solution pocks upward; small *Strophomenids* center	10	
2.	Dolomite, buff, massive; *Strophomena* and *Streptelasma*	2	6
1.	Dolomite, buff, thin-bedded, iron stains; fucoids, small gastropods	3	
	Base of quarry		

ROADSIDE EXPOSURE, THREE MILES SOUTHEAST OF ROCK CITY, EAST BLUFF OF ROCK RUN CREEK, NW.¼ NW.¼ Sec. 2, T. 27 N., R. 9 E., PECATONICA QUADRANGLE

	Covered.	Thickness Ft.
13.	Dolomite, buff, weathers sugary	1
12.	Dolomite, buff, a few traces of green shale, weathers sugary	7
11.	Dolomite, buff, greenish, shaly; *Dalmanella* common	1
10.	Dolomite, sugary, a few shaly partings; crinoid fragments, *Sowerbyella*, *Strophomena*, dwarf *Receptaculites* above	4
9.	Dolomite, buff, green, shaly	3
8.	Dolomite, weathers sugary; cf. *Sowerbyella*, cf. *Pionodema*	5
7.	Dolomite, partly covered, buff, beds two to six inches thick, chert sparing	8
6.	Dolomite, buff, iron-stained, thin-bedded, fucoidal	1
5.	Dolomite, buff, scattered chert; silicified *Streptelasma* and *Columnaria*; solution pocks scattered	4
4.	Dolomite, buff, cherty	1
3	.Dolomite, buff; silicified *Streptelasma* above	6
2.	Dolomite, buff, medium to fine grain; sparingly fossiliferous	3
1.	Dolomite, buff, fucoids sparing; *Strophomena*, *Streptelasma*, *Leperditia* profuse	1

Criteria found useful in determining the relative placement of Decorah strata in the area follow:

1. Zones crowded with *Dalmanella*, and scattered crinoid fragments with *Glyptorthis*.

2. An occasional dwarfed form of *Receptaculites* associated with, or a few feet above, the *Dalmanella* zones in transitional upper Decorah beds.

3. *Leperditia cf. fabulites* commonly scattered 8 to 15 feet below the *Dalmanella* zones.

4. Silicified fossils, scattered in upper Platteville, most common of which are *Columnaria* and *Streptelasma corniculum*.

5. Profuse fucoids scattered on the bedding planes mostly in the upper Platteville, but extending up into the Galena formation.

6. Blue-green shaly partings on wavy bedding planes, more common in lower Decorah strata.

7. Black and dark brown mineral specks, probably manganese, with dendrites.

8. Locally, buff to brown shaly partings in upper Platteville beds.

9. Locally, *Pionodema* underlying Decorah shales.

The base of the shaly dolomite Decorah formation can be identified at exposures with a fair degree of accuracy. The Platteville-Decorah contact is therefore used as a key horizon in mapping structural trends in the quadrangle. Outcrop elevations on the top of the Platteville, which provides most of the control, are estimated from contour maps. Use of well logs is limited because the Decorah formation is not delimited in the older wells.

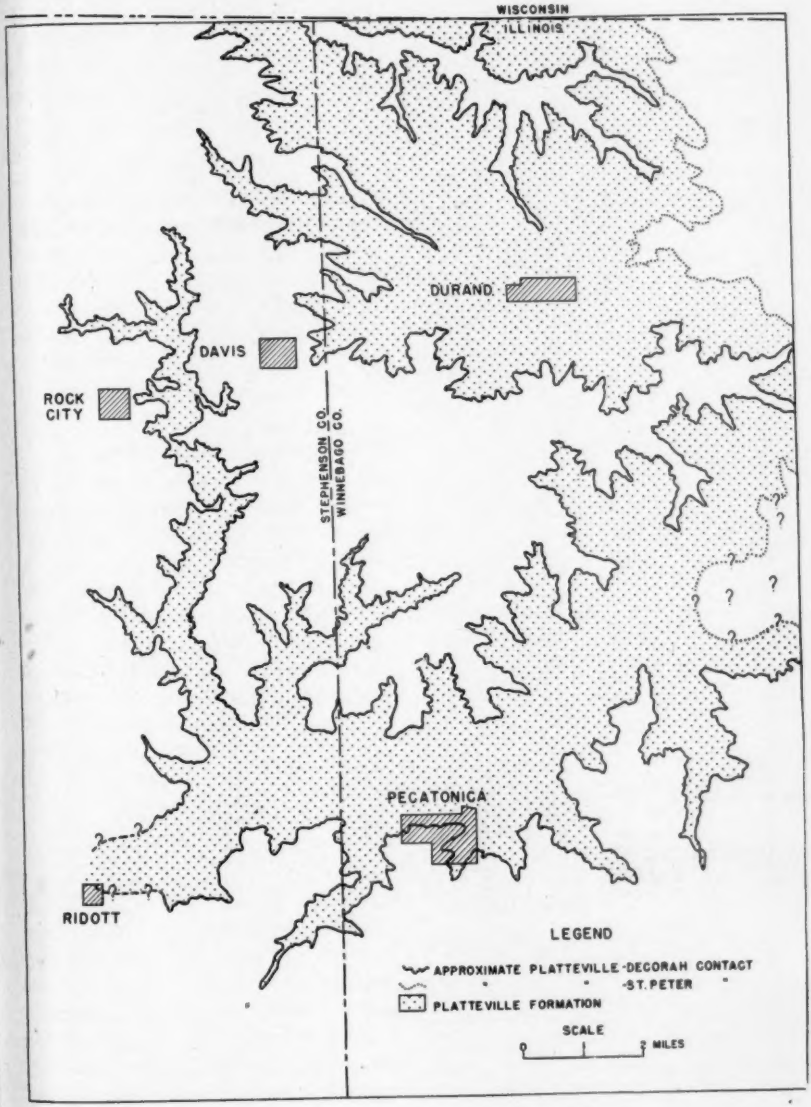
Two maps are presented. Fig. 1 shows the approximate Platteville-Decorah contact. Fig. 2 shows structural trends by contours drawn on the top of the Platteville formation.

In general, the structural trends in the area follow maps drawn on the top of the Galena.[4] The west part of the area shows a marked syncline with north-south axis, named herein the Rock Run syncline. The north center exhibits a gentle arch pitching southward at about 25 feet per mile. The axis is approximately north-south through the central part of the quadrangle and marks the south central margin of the Wisconsin arch. The village of Pecatonica is on the crest of the arch, near its southern extremity. In the extreme northeast a syncline trends northwest-southeast, the axis of which is near the village of Avon, Wisconsin. From the east-center margin of the quadrangle a small flexure pitches southeastward in the direction of Rockford. A structural sag is in the southern part of the quadrangle, whose long axis trends east-west. This feature is probably a part of structure referred to as the Ogle county line syncline.[5]

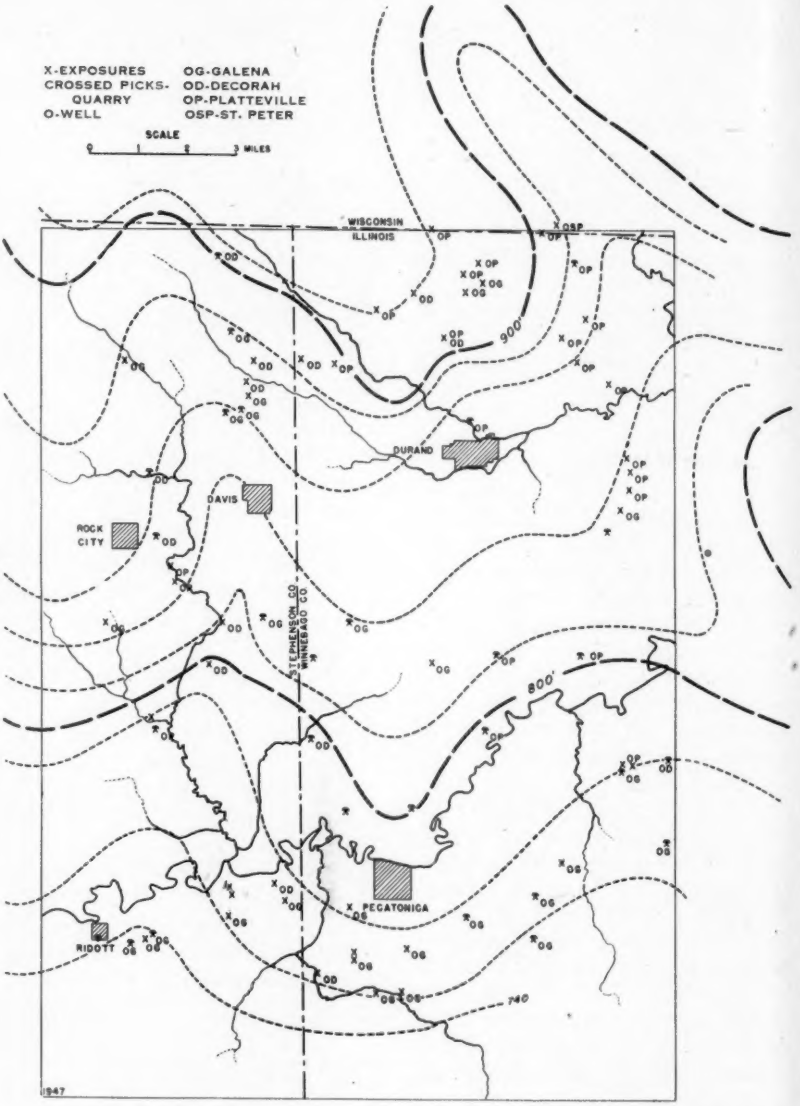
Strata exhibiting moderate dips of from 5° to 10° are at two locations: (1) Three miles southeast of Rock City, east bluff of Rock Run Creek at roadside, NW. ¼ NW. ¼ sec. 2, T. 27 N., R. 9 E., and (2) two miles south southeast of Ridott, SE. ¼ SE. ¼ SW. ¼ sec. 4, T. 26 N., R. 9 E. This latter location may represent slump in an area of solution.

[4] Horberg, Leland, Preglacial erosion surfaces in Illinois: Illinois Geol. Survey Rept. Inv. 118, p. 185, 1946.

[5] Cady, G. H., Structure of the LaSalle anticline: Illinois Geol. Survey Bull. 36, p. 132, 1920.



Generally, the area is one of gentle warping and southward pitch, in which nearly all exposures exhibit strata horizontal in attitude. Exten-



sion of structural trends studied northward across the state line into Wisconsin indicate cross structures present in the northern part of the South Wayne, Monroe, and Brodhead quadrangles.

GEOLOGICAL APPLICATIONS OF THE IONIC POTENTIAL

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Introduction

Quite frequently we are reminded that the 96 known chemical elements are too complex to be classified by reference to any single characteristic. The periodic classification gives us only qualitative ideas, and many attempts have been made to place the elements on a more quantitative scale.

The role of ionic radii in the properties of chemical compounds has been emphasized by many authors including Pauling, Goldschmidt, and Bragg. Another factor influencing the properties of chemical compounds is the oxidation number or charge which an ion carries. In order to obtain a more comprehensive view of an ion and its properties, we must take into consideration both of these factors.

Definition

Increasing ionic charge and ionic radius act in opposite directions. That is, the lattice energy of a crystal is directly proportional to the charges and inversely proportional to the radii of the ions contained therein. From these considerations, Cartledge (1, 2) defined the ionic potential ($\varnothing$) as the charge on an ion divided by its radius. Table 1 gives a list of some common ions, their charges, radii, ionic potentials, and the square roots of their ionic potentials.

Table 1. Ionic Potentials

Ion	Charge	Radius*	$\varnothing$	$\sqrt{\varnothing}$
Cs^{+}	1	1.65	0.61	0.78
Rb^{+}	1	1.49	0.67	0.82
K^{+}	1	1.33	0.75	0.87
Na^{+}	1	0.98	1.02	1.00
Ba^{++}	2	1.43	1.40	1.18
Pb^{++}	2	1.32	1.52	1.21
Sr^{++}	2	1.27	1.58	1.26
Li^{+}	1	0.78	1.67	1.30
Ca^{++}	2	1.06	1.89	1.38
Zn^{++}	2	0.83	2.40	1.55
Fe^{++}	2	0.83	2.40	1.55
Mg^{++}	2	0.78	2.56	1.60
Th^{+4}	4	1.10	3.63	1.91
Ce^{+4}	4	1.02	3.92	1.98
Fe^{+++}	3	0.67	4.48	2.12
Zr^{+4}	4	0.87	4.60	2.15
Pb^{+4}	4	0.84	4.76	2.18
Al^{+++}	3	0.57	5.26	2.30
Be^{++}	2	0.34	5.90	2.43
Ti^{+4}	4	0.68	5.90	2.43
Mo^{+6}	6	0.62	9.7	3.11
Si^{+4}	4	0.39	10.2	3.18
P^{+5}	5	0.34	14.7	3.82
B^{+++}	3	0.20	15.0	3.87
S^{+6}	6	0.29	20.0	4.46
C^{+4}	4	0.20	20.0	4.46
N^{+5}	5	0.11	45.5	6.70

*The radii have been taken from V. M. Goldschmidt, Br. 60, 1263 (1927).

These values of the ionic potential may be related to many geological concepts, of which seven will be considered.

Applications

1. If the square root of the ionic potential ($\sqrt{\varnothing}$) of a cation is less than 2.2, the oxide formed will be basic; if $\sqrt{\varnothing}$ is between 2.2 and 3.1, the oxide will be amphoteric; and if $\sqrt{\varnothing}$ is greater than 3.1, the oxide will be acidic. These data are summarized in Table 2 along with some examples.

TABLE 2.—ACIDIC-BASIC CHARACTER OF OXIDES

$\sqrt{\emptyset}$	Nature of oxide	Examples
<2.2	basic	Na_2O, K_2O, CaO, MgO
2.2-3.1	amphoteric	Al_2O_3, BeO
>3.1	acidic	SiO_2, CO_2

2. When the $\sqrt{\emptyset}$ of the cation of a chloride is greater than 2.2., the chloride is volatile at a little above room temperature and one atmosphere pressure. This means that the chlorides of silicon, germanium, titanium, plumbic lead, etc. could be lost in volcanic eruptions.

3. The hardness of binary crystals increases as the ionic potentials of their constitutents increase. This phenomenon is illustrated in Table 3.

4. If the $\sqrt{\emptyset}$ of the cation of a carbonate or nitrate is greater than 2, the compound will not be stable; if $\sqrt{\emptyset}$ is between 2 and 2.5, basic carbonates are formed which are soluble in carbonate solution. Thus, zirconium, aluminum, beryllium and others may be dissolved in carbonate solutions as basic carbonates.

5. Goldschmidt (3, 4) has divided the cations into three groups according to their ionic potentials. Group I consists of cations whose ionic potentials are less than 3; they remain in true ionic solution in the processes of weathering and transportation. An example of this is the presence of sodium, potassium, magnesium, calcium, and strontium in sea water. Group II is made up of cations which have ionic potentials between 3 and 6. These ions are precipitated by hydrolysis, examples being the presence of aluminum and beryllium in clays. Cations with ionic potentials greater than 6 comprise Group III. They form complex anions containing oxygen, some of them again being soluble. Examples of these are the silicates, phosphates, carbonates, borates, and nitrates.

6. Elements whose ionic potentials are less than 2 are found to be easily collected and exchanged by natural zeolites.

7. Elements with high ionic potentials enrich in silicates. Goldschmidt (4, 6) says that the limit is about 2.6 at ordinary temperature, but that the limit changes with the temperature.

TABLE 3.—HARDNESS OF BINARY CRYSTALS

Compound	NaF	MgO	ScN	TiC
Hardness (Moh's)	3.2	6.5	7-8	8-9
$\sqrt{\emptyset}$ cation	1.00	1.60	1.90	2.43
$\sqrt{\emptyset}$ anion*	0.86	1.19	1.32	1.38

*Values for the anions are calculated by neglecting the negative sign to facilitate the taking of the square root.

Conclusions

The concept of the ionic potential is very useful to the instructor as a teaching aid, and also to the research worker as a simple means of remembering various relations. The user is warned, though, because the idea is not infallible; but it is nevertheless applicable to many problems. Other references are provided for further reading.

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UNUSUAL OOLITE GRAINS FROM THE STE. GENEVIEVE LIMESTONE*

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In connection with other studies of Illinois limestone resources it was noted that a massive bed of oolite, 6 to 8 feet thick, in the upper part of the Ste. Genevieve formation in the quarry at Anna, Illinois, contained oolite grains and other grains of unusual character as compared to the common Ste. Genevieve type oolite grains, which are characterized by rounded centers, mostly of undeterminable origin surrounded by one or more annular calcite deposits. Pictures of a number of these unusual grains are included. No attempt is made to interpret the origin of the grains themselves, or their broader significance in relation to the mode of formation or subsequent history of the Ste. Genevieve formation, because the data now available are inadequate, but some interesting possibilities are self-evident from the pictures (figs. 1-6).

The specimens studied were prepared by sawing and grinding a plane surface on each, and etching the surface with dilute hydrochloric acid. This produced a semi-polished finish which revealed well the textural details of the specimens. Insoluble impurities projected above the surfaces of the specimens. The figures shown are made from photomicrographs taken by reflected light at magnifications of 12 to 30X, except as otherwise noted.

The unusual grains observed may be classified into five groups: (1) oolite grains with recognizable fossils as centers; (2) compound oolite grains; (3) grains composed of oolite rock; (4) oolite grains with clear crystalline calcite centers; and (5) partial or disrupted grains. The number of photomicrographs shown for each type of grains is not necessarily proportional to the numbers occurring in the samples studied.

Heinz Lowenstam of the Survey staff identified the fossils.

Description of Figures

Figure 1 is a photomicrograph of typical Ste. Genevieve oolite taken at a magnification of 10X. Some grains have large dark calcite centers surrounded by a single ring of calcite. Others have smaller centers with one or more annular deposits around the center. The dark areas between the grains are also clear crystalline calcite in this figure and other figures which follow.

Figure 2 shows grains of the type that have fossils as centers. In the upper left is an oolite grain composed of a foraminifera, possibly endothyra, surrounded by a single ring of calcite. In the lower left is a grain whose center is an arm plate of a crinoid having two annular deposits around it. Grains with crinoid arm plate centers are generally abundant in the Ste. Genevieve oolite. The grain in the upper right shows a longitudinal cross-section of a minute gastropod surrounded by a

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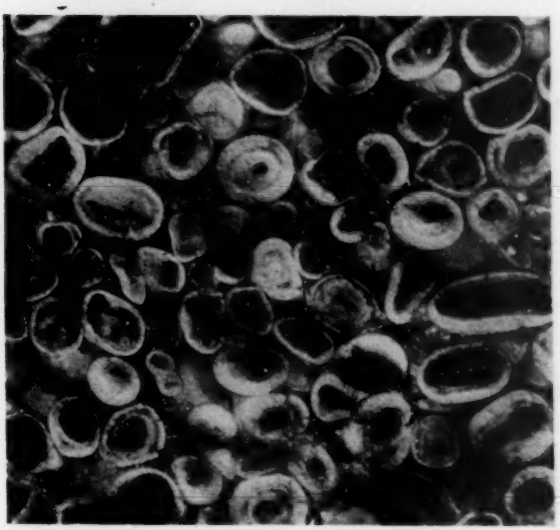

FIG. 1.—Typical Ste. Genevieve oolite.

FIG. 2.—Oolites with recognizable fossil centers.

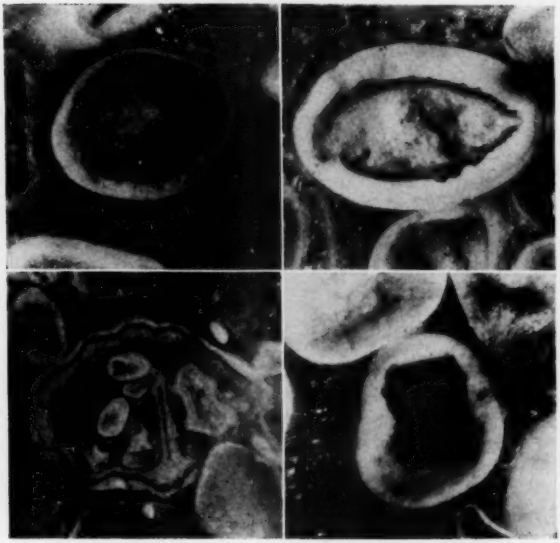

FIG. 3.—Oolites with recognizable fossil centers.

single thick calcite ring. The grain at the lower right is a fossil, not positively identified, but possibly a longitudinal section of a crinoid stem showing a residual central canal. Note the thinness of the calcite ring around this fossil. This last photomicrograph has a magnification of 12X as compared to 30X for the other grains shown.

Figure No. 3 shows more grains with fossil centers. In the upper left is a cross-sectioned coral with a single calcite ring. A transverse cross section of a brachiopod with a single thin white calcite ring is shown in the lower left. The interior of the brachiopod contains other smaller oolite grains. In the upper right is another brachiopod in longitudinal cross section surrounded by a thick deposit of calcite, as is likewise a piece of crinoid stem in the lower right, which is displayed in longitudinal cross section. All grains shown have a magnification of 30X.

Figure No. 4 shows in the upper left a compound oolite grain having two well defined centers surrounded by annular calcite deposits. A third center appears on the right side of the grain. The outermost thin calcite ring surrounds this third center as well as the rest of the composite grain. The other grains shown in the figure are oolite rock. They have no annular deposits around them and appear to have been derived from a consolidated oolite which was being eroded at the time the bed from which these specimens came was deposited. The oolite grains within the fragments of oolite rock are of the type previously described as usual for the Ste. Genevieve formation. The photomicrographs in

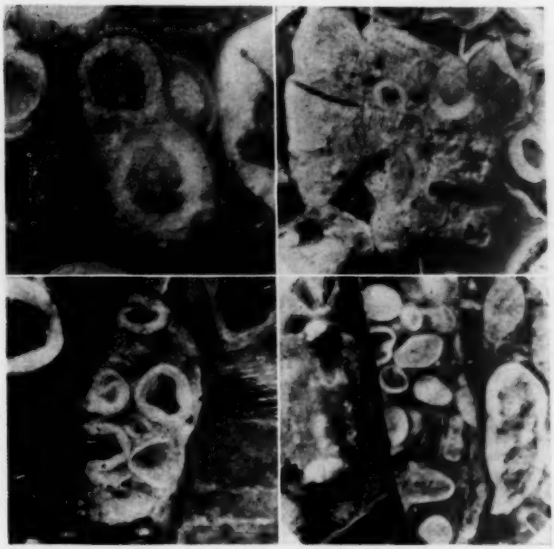

FIG. 4.—Compound colite grain and grains of oolite rock.

FIG. 5.—Compound oolite grain and grains with clear crystalline calcite centers.

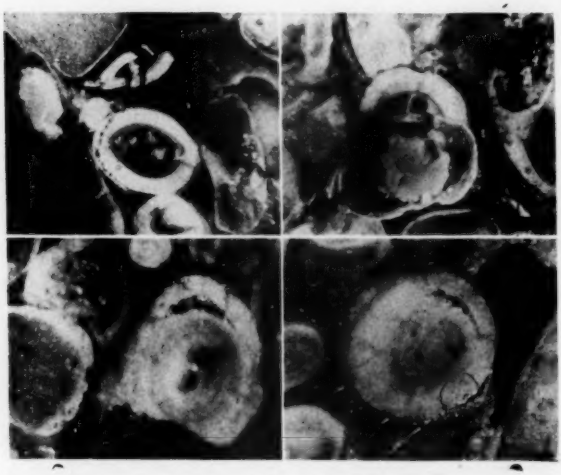

FIG. 6.—Partial grains and disrupted grains.

this figure have a magnification of 12X, excepting the upper left which has 30X.

Figure No. 5 shows in the upper left another compound grain with 3 centers, all enclosed by a calcite ring. The remainder of the figure illustrates oolite grains with clear calcite centers, which in the photomicrographs are dark gray or nearly black. The grain in the lower left is one whose center is only half crystalline calcite. The grain in the upper right appears to have had a brachiopod, shown in longitudinal cross section, as its center. The white calcite envelope on the concave side of the shell is of unusual thickness. The grain in the lower right is of interest because of its angular outline. The photomicrographs in this figure have a magnification of 12X.

Figure No. 6 shows the disrupted and partial grain type. In the lower left disruption of the exterior portion of the grain is evident, probably as a result of the growth of crystalline calcite, indicated by the dark area. The same phenomenon is shown in the grain at the lower right and in the upper left. Also in the upper left there appears the white calcite envelope of an oolite grain which has been broken and deformed and whose center is no longer evident. Partial grains, which appear to be the result of the solution of one grain at its contact with another, are well shown on the left side of the lower left picture. In the upper right picture, a series of two partial grains are shown. In the whole grain projecting silica casts a shadow on the surface. The photomicrographs in this figure have a magnification of 25X with the exception of the upper right which has 10X.

PHYSICS

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7. The Endurance Limit of a Free-cutting Brass Rod: H. L. WALKER and M. BASKAL, University of Illinois, Urbana.

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ENDURANCE LIMIT OF A FREE-CUTTING BRASS ROD

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Free-cutting brass rod is the most important of all the leaded brasses. Each year millions of pounds are consumed in the manufacture of screws, nuts, bolts, door hinges, and general hardware of all kinds. This product has excellent plasticity within the temperature range of 1200° to 1450° F. and can be extruded into intricate shapes; however, it cannot be hot-rolled or forged because of its high lead content. It is usually fabricated by hot extruding and/or cold drawing to size and shape. For best machining properties the product is furnished in the cold drawn condition.

Lead is virtually insoluble in alloys of copper and zinc, and when present it occurs as finely divided and more or less evenly distributed globules of lead. The presence of lead in brass does not appreciably influence the mechanical strength or corrosion resistance of the parent alloy but it does drastically reduce the bending, cold-heading, and upsetting operations, which can be performed with comparative ease in most of the unleaded copper-zinc alloys. The one reason why lead is added to brass is to improve its machinability. The presence of lead uniformly distributed in a brass alloy causes chips to break off and, since the chips are practically undistorted and are only momentarily in contact with the tool face, very little heat is transmitted to the cutting tool.

Purpose of Investigation

Free-cutting brass rod is essentially common brass rod (63% Cu, 37% Zn) to which approximately 3% Pb has been added. The presence of lead does not appreciably influence the mechanical strength of the common brass rod as is shown by the following data: Common brass rod, 62.7% Cu; Pb 0.03%; Zn balance, grain size 0.045 mm. diameter ready-to-finish, cold drawn 30%, has a tensile strength of 70,000 psi. Free-cutting brass rod, 61.7% Cu; 3.35% Pb; 34.9% Zn, grain size 0.040 mm. diameter ready-to-finish, cold drawn approximately 30%, has a tensile strength of 67,000 psi.

Because of the presence of lead particles in the microstructure of free-cutting brass rod there is an excellent opportunity for the lead to act as stress-raisers and materially affect the endurance limit. There are only a limited number of references in the literature to the endurance limit of leaded brasses, therefore it was believed that such an investigation would be of value.

Apparatus

All tests were made on a Farmer machine of rotating simple beam type, in which the outermost fibers of a solid cylindrical specimen are subjected to cycles of completely reversed stress from tension to compression, under constant load.

*An abstract of a thesis presented by M. Baskal in partial fulfillment of the requirements for the degree of Master of Science in Metallurgical Engineering, University of Illinois.

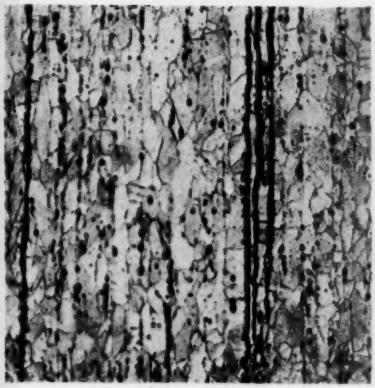

FIG. 1.—Brass rod, cold drawn approximately 30%. Structure shows grains of alpha and beta solid solution. The dark stringers are particles of undissolved lead. Average grain size 0.040 mm diameter. Etched with 1 part H_2O_2 plus 4 parts 50% NH_4OH. Magnification 100 diameters.

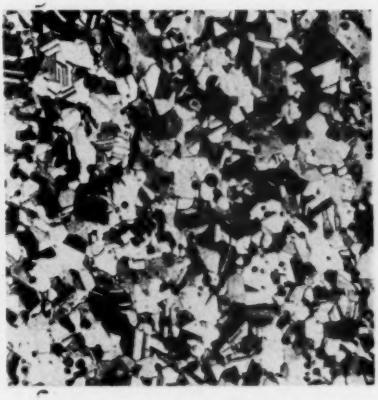

FIG. 2.—Brass rod annealed at 1050° F. for 2½ hours. Elongated grains of cold-drawn condition have been replaced by strain free equiaxed grains. Structure is essentially alpha solid solution grains with coalesced globules of lead. Grain size 0.040 mm diameter. Magnification 100 diameters. Etched in hydrogen peroxide plus ammonium hydroxide.

The specimens were of standard size: 4.0 inches long, 0.300 + 0.003 inch minimum diameter, and 5.0 inch radius. The ends of the specimens were threaded internally to facilitate a tight grip in the chucks. The surface was polished parallel to the axis with No. 00 metallographic paper.

MATERIAL AND PROCEDURE

The free-cutting brass rod was of ⅝ inch diameter, cold-drawn approximately 30%, with a ready-to-finish grain size of 0.040 mm. diameter.

The chemical analysis was:

Copper	61.70%
Lead	3.35%
Zinc	34.90%
Total	99.95%

The structure of the bar in the as-received condition consisted of alpha and beta brass, plus particles of lead; and the structure is illustrated in figure 1.

A series of as-received brass specimens was given a heat treatment to eliminate beta brass and produce a grain size equal to the ready-to-finish grain size. The treatment consisted of heating to 1050° F., holding for 2½ hours at that temperature in an electrical resistance furnace, followed by quenching in water. The grain size produced averaged 0.040 mm. diameter. The structure showed complete recrystallization but no appreciable beta phase, and is illustrated in figure 2. Another series of brass specimens was heat treated to produce a grain size twice as large

as the ready-to-finish grain size and to eliminate the presence of beta phase. The heat treatment consisted of heating to 1500° F., holding for 3½ hours at that temperature, cooling to 1050° F. and holding at 1050° F. for 7½ hours, followed by quenching in water. The grain size produced averaged 0.080 mm. diameter. The structure showed complete recrystallization and coalescence of the grains but no beta phase, and is illustrated in figure 3.

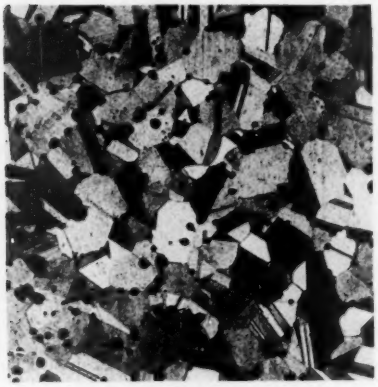

FIG. 3.—Brass rod annealed at 1500° F. for 3½ hours. Structure consists of alpha solid solution and globules of lead. Grain size 0.080 mm diameter. Magnification 100 diameters. Etched in hydrogen peroxide and ammonium hydroxide.

The specimens were rough machined, heat treated, finish machined, and polished. An initial load of approximately 0.6 times the tensile strength was used. The load was continuously reduced until failure did not take place in 50 million cycles of reversed stressing. The specimens annealed at the higher temperature, to produce a large grain size, could not be loaded with a load greater than 25,000 psi without causing plastic deformation when the load was applied.

TABLE 1.—FATIGUE AND MECHANICAL PROPERTIES OF FREE-CUTTING BRASS ROD

Material	Rockwell B hardness	Ultimate strength psi	% Elongation in 1.2 inch gage length	% Reduction of area	Endurance limit psi	Cycles of stress
Brass, cold drawn approx. 30%. Av. grain dia. 0.040 mm.	73	67,000	22.4	51.1	16,500	$50x10^6$
Brass annealed 2½ hrs. at 1050° F. Av. grain dia. 0.040 mm.....	17	52,000	64.1	51.6	18,000	$50x10^6$
Brass annealed 3½ hrs. at 1500° F., cooled to 1050° F., held 7½ hrs. Av. grain dia. 0.080 mm.	13	45,300	65.2	58.5	17,500	$50x10^6$

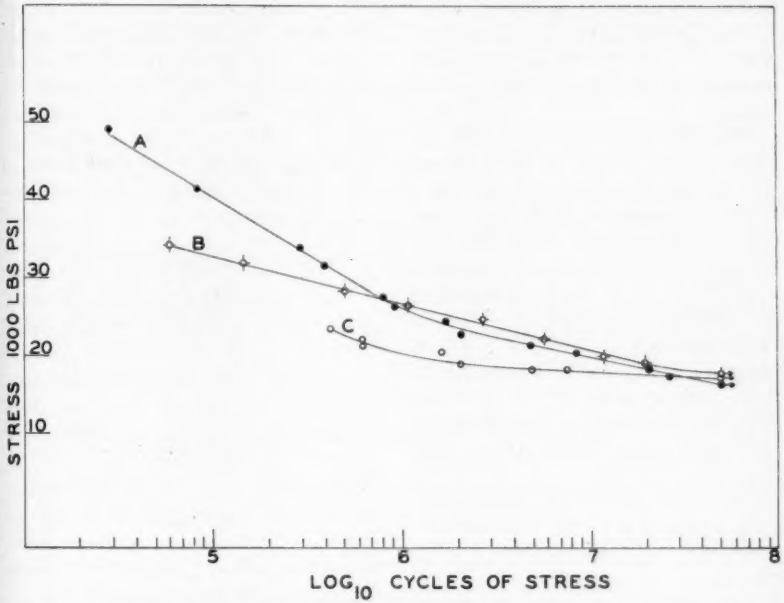

FIG. 4.—Stress versus cycles of stressing to produce failure in a free-cutting brass rod.

Curve A. Cold-drawn approximately 30% reduction in area.

Curve B. Annealed at 1050° F.

Curve C. Annealed at 1500° F.

Arrows indicate no failure for conditions of stress and cycles of stressing.

DISCUSSION OF RESULTS

The mechanical properties of the free-cutting brass rod in the three conditions of testing are shown in table 1. The loss in hardness and strength, and increase in elongation with the first heat treatment, shows recrystallization was complete and coalescence of grains had taken place. When the grain size was doubled by coalescence, in the second heat treatment, a further loss in strength and hardness was found, but the ductility was less affected.

The stress in pounds per square inch and the number of cycles of reversed stressing, to produce failure, are tabulated in table 1; and the data are plotted in figure 4 in the conventional manner of stress vs. cycles of stressing on a semi-logarithmic plot.

The rod in the as-received condition with approximately 30% cold deformation showed a continuously lowered stress for cycles of stressing up to 50,000,000 cycles. The slope of the curve for failure decreases at stresses of less than 25,000 psi. However, with cycles of stressing up to 50,000,000 cycles the S-N curve had not become horizontal, and a stress

had not yet been reached in which it could be said a safe load had been reached for an infinitely large number of repeated cycles of stressing.

The specimens which had been annealed for 2½ hours at 1050° F., and with the same grain size as the ready-to-finish grain size before cold drawing, show an initially lower stress for a small number of cycles. The relation of stress vs. cycles of stressing is linear from 200,000 to 10,000,000 cycles of stress. Curiously, the load-carrying ability of these specimens, for cycles of stressing greater than 1,000,000 and up to 50,000,000, is somewhat better than for the cold drawn specimens.

The specimens which had been annealed for 3½ hours at 1500° F., followed by holding at 1050° F. for 7½ hours, would not take an initial load in excess of 25,000 psi without plastically deforming under the load. The load-carrying ability of these specimens of large grain size was materially lower than for the cold drawn specimens, or for the specimens annealed at the lower temperature and with a grain size only half as large. The relation of stress vs. cycles of stressing is linear and parallel to the specimens of smaller grain size with cycles of stressing up to 5,000,000 cycles. At 5,000,000 cycles the slope of the curve decreases and the curve is practically h o r i z o n t a l from 5,000,000 to 50,000,000 cycles.

The three curves, for the three specimens in different conditions, practically meet at a constant value of stress for 50,000,000 cycles of stressing. Thus, it is indicated that for an infinitely large number of cycles the annealed rod has the ability to carry as large a load as the cold drawn rod.

Conclusions

Based upon the results obtained in this experiment the following conclusions may be summarized:

1. Cold drawing of leaded-brass does not increase the load-carrying ability of the metal for 50,000,000 cycles of reversed stress.

2. Based upon 50,000,000 cycles of reversed stressing there is no indicated safe load for an infinite number of reversals of stressing, such as is exhibited by ferrous alloys.

3. Cold drawing a leaded-brass does increase the load-carrying ability, under complete reversal of stressing, for cycles of stressing less than 1,000,000 cycles.

4. The endurance limit of leaded-brass is not affected by increasing the grain size from 0.040 to 0.080 mm. diameter, for a large number of stress cycles.

5. It may be safely concluded that the globules of insoluble lead found in leaded-brass tend to act as localized stress raisers and thus prevent the homogeneous distribution of stress across the matrix of the alloy.

PSYCHOLOGY AND EDUCATION

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* 2. Basic Misunderstandings between Professors of Liberal Arts and of Education: EDWIN H. REEDER, University of Illinois, Urbana.

* 3. National Study of Teacher-education Scholarships: EUGENE R. FAIR, Southern Illinois Normal University, Carbondale.

* 4. Causes of Severe Reading Retardation: HELEN ROBINSON, University of Chicago, Chicago.

* 5. Testing our Tests of Physical Fitness: D. M. HALL, University of Illinois, Urbana. (movie and slides)

* 6. Research in Progress in the Student Personnel Bureau at the University of Illinois: WILLIAM M. GILBERT, University of Illinois, Urbana.

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*11. Predicting Teacher Success: EMILY G. DUNN, LINDSEY MORRIS, and JAMES GOFF, Illinois State Normal University, Normal.

12. Sex Deviatons in the Selection of Masculine and Feminine Words in Poetry: DAVID MANNING WHITE, Bradley University, Peoria.

* Not published.

SEX DEVIATIONS IN THE SELECTION OF MASCULINE AND FEMININE WORDS IN POETRY

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The question as to whether words in the English language possess valences toward "masculinity" or "femininity" is, of course, a very complex one. At one time or another, however, almost everyone has heard someone say, or perhaps has thought to himself, this word has a distinctly *feminine* sound, or that word is certainly *masculine*.

The purpose of this brief study is to examine the differences in the selection of "masculine" and "feminine" words by 100 male students and 100 female students at Bradley University. Although this is merely a preliminary study, the results seem to indicate that an examination of the subject's attitude toward words from poetry can serve as a projective technique in order to ascertain *maleness* or *femaleness* in the subject.

The students who participated in this test were given a mimeographed sheet of paper with the three poems. The authors of the poems were, obviously, not given. The students were asked to designate whether they thought the poem was written by a man or woman. They were asked, secondly to list any words, which, in their opinion were masculine or feminine sounding. They were asked to list the masculine or feminine words which had been instrumental in determining for them that the writer of the poem was a man or woman.

The same students who took the poetry test were later given a second test. This is a preliminary test by Arthur Weider, Assistant Professor of Psychology at Bradley University, which sets up a masculinity-femininity scale. This is done by filling out a work-interest blank, which is a disguised occupational preference blank, wherein the subject encircles L (Like) or D (Dislike) for a list of twenty occupations. The subjects are asked to indicate in this list those which he likes or dislikes. A previous study of homosexuals incarcerated at Rikers Island, a penal institution in New York harbor, for asocial behavior, as well as effeminate and homosexual subjects, demonstrated in a statistically reliable manner that certain occupations, e.g., interior decorator, dancer, window dresser, etc, were chosen by these homosexuals with great frequency. This fact is utilized in the Weider scale for the purpose of deriving conclusions concerning the individual's ability to accept the male patterns of our society.

Examining the selection of words from the poetry in a general way, it is interesting to note that in the list of feminine words chosen by male subjects the words *lovely* and *desired* have high frequencies, while neither word was in the corresponding female list. The strong feminine connotation of the word *sea* for male

subjects was not shared by the women. In only one word did both sexes concur; both chose *lilies* as the most feminine word.

Perhaps more significant are the female choices in this respect. The female choices of the feminine words suggest the spring season of the year. The period of growth and verdancy is perhaps strongest in the female mind as the symbol of fertility and motherhood. On the other hand, the female choice of masculine words reveals an almost diametric concept, one that suggests winter and hiemal dormancy.

In both groups the word *storms* had a very high masculine frequency, as did the words *hail* and *wind*.

How can such word choices serve as a projective technique in determining maleness or femaleness in the subject? To validate the frequency lists the individual tests, i.e. selecting the words from the poetry, were compared with the same subject's score on the Weider masculinity-femininity scale For example, subject A, female, 19 years old, had an M-F score of F-5, which indicates an adequate acceptance of female patterns. The words that she listed as feminine included *lilies, silently* and *spring;* her masculine choices included *storms* and *death*. In only one word did she go over to the male lists. That was her choice of *sea* as a feminine word.

Another female subject, age 20, had a very high F score on the F-M scale, an F 22, indicating a very strong acceptance of the female patterns and/or rejection of the male patterns. The four words she selected, *lilies, green swell* (in her feminine selections) and *storms* and *scalding* (in her masculine selections) are exclusively in the female frequency lists.

Another female subject, age 22, had a score of M-8 on the M-F scale, indicating a deviation from the acceptance of female patterns. Accordingly, one could expect a selection on her part of several words from the male frequency lists. Of the five words she listed, two of them came from the male lists, *sea* and *desired*, and the other three words were those which were common to both groups, i.e., *lilies, storms* and *wind*. She chose no words from the female frequency lists.

Collating the individual male tests with the same subject's M-F scale produced similar results to the cases which I have just listed. It should be understood, however, that there were several cases, both male and female, in which the words selected did not follow the general trend. Although they showed a good acceptance of maleness or femaleness on the M-F tests, the subjects selected words from the opposite sex's frequency list. However, it may be significant to point out that a very large percentage of the subjects had a close correlation between their M-F scales and the words which they selected as masculine and feminine. Of the women tested 78 percent chose words from the frequency lists in proportion to their M-F scales, and 69 percent of the men did the same.

As I have suggested, this study is merely the preliminary step in a very complex problem. If, however, further testing, perhaps with different and better poems, continues to indicate that there is a strong cor-

relation between the M-F scale and the words selected, a test can be devised which will serve as a projective technique to further ascertain acceptance or deviation from the male or female patterns of our society.

POEMS USED IN STUDY

1

I have desired to go
Where spring not fail,
To fields where flies no sharp and sided hail.
And a few lilies blow.

And I have asked to be
Where no storms come,
Where the green swell is in the haven dumb,
And out of the swing of the sea.

—Gerard Manley Hopkins

2

White sky, over the hemlocks bowed with snow
Saw you not at the beginning of evening the antlered buck and his doe
Standing in the orchard? I saw them. I saw them suddenly go,
Tails up, with long leaps lovely and slow,
Over the stone-wall into the wood of hemlocks bowed with snow.

Now lies he here, his wild blood scalding the snow.

How strange a thing is death, bringing to his knees, bringing to his antlers,
The buck in the snow.
How strange a thing,..a mile away by now, it may be,
Under the heavy hemlocks that as the moments pass
Shift their loads a little, letting fall a feather of snow—
Life, looking out attentive from the eyes of the doe.

—Edna St. Vincent Millay

3

Now close the windows and hush all the fields;
If the trees must, let them silently toss;
No bird is singing now, and if there is,
Be it my loss.

It will be long ere the marshes resume.
It will be long ere the earliest bird.
So close all the windows and not hear the wind,
And see all wind-stirred.

—Robert Frost

Lists of the five most frequently selected words in each category chosen by male and female students.

Male Students		*Female Students*	
Masculine Words	Feminine Words	Masculine Words	Feminine Words
1. wind (41)	1. lilies (54)	1. storms (57)	1. lilies (48)
2. storms (38)	2. lovely (51)	2. hail (46)	2. spring (41)
3. hail (33)	3. desired (42)	3. scalding (39)	3. green swell (36)
4. snow (30)	4. sea (37)	4. death (33)	4. silently (29)
5. blood (27)	5. feather (31)	5. wind (28)	5. feather (17)

SOCIAL SCIENCE

S. R. KAMM, *Chairman*
Wheaton College, Wheaton

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* 1. The Autonomy of Scholarship: DANIEL J. BOORSTIN, University of Chicago, Chicago.

2. Problems of Constitutional Reform in Illinois: LYNFORD A. LARDNER, Northwestern University, Evanston.

* 3. Culture Pattern of an Ethnic Island in Rural Wisconsin: OSCAR F. HOFFMAN, Elmhurst College, Elmhurst.

* 4. Cultural Areas in Peoria: CLARENCE W. SCHROEDER, Bradley University, Peoria.

5. Problems of Old Age in a City of 100,000: RUTH SHONLE CAVAN, Rockford College, Rockford.

* 6. Residential Development in Suburban Milwaukee County: RICHARD DEWEY, University of Illinois, Urbana.

*Not published.

OLD AGE IN A CITY OF 100,000

RUTH SHONLE CAVAN
Rockford College, Rockford

Rockford is an industrial city in northern Illinois, which had a population in 1940 of approximately 85,000 within the city limits and 20,000 in the suburbs immediately adjacent to the city. Of the urban population, 6,458 were aged 65 and over and of the suburban population, 988. As is true of many cities, this community is just beginning to realize that old age presents many serious problems in addition to the economic one.

An understanding of old age problems, both psychological and social, must rest upon a factual survey of the type of old people in the community and of their living arrangements and activities.[1] The Census for 1940 gives an over-all picture of the type of old people who live in the community and where they live. Additional material comes from interviews with 205 persons aged sixty and over and from community agencies, industries, and churches.

In general, old age is a problem which has crept into the community unnoticed and which will not reach its full significance for some years to come. In Rockford, the percentage of the population that is 65 years of age and over has increased from 5.1 in 1900 to 7.6 in 1940. For the suburbs in 1940 the percentage was slightly lower, 7.0. In accordance with estimated future increases for the total United States, old people in Rockford will probably reach 11 or 12 percent of the population by 1980.[2] Old people in Rockford as in other cities represent an increasing group whose needs must receive attention if the community is to avoid having a fairly large segment of its adult population without integration in the community life.

Whenever part of the population can be set off with some definite characteristic there is a tendency to think of the members of the group as all being very much alike and to apply stereotyped attitudes to them. Old people are not all alike. In fact they are as different in personality and in social experiences as any other group of adults classified by age.

In Rockford, which has several foreign-born communities, 45 percent of all persons 65 years of age and over are foreign-born; 0.7 percent are Negroes. The foreign-born represent a far greater proportion of the old people than they do of the total population, for only 16 percent of the total population are foreign-born. The Negroes represent a smaller percentage, as 1.4 percent of the total population is Negro. The foreign-born in Rockford are essentially Swedish and Italian. The peak of immigration was sometime in the past so that the foreign-born repre-

[1] Much of the material used in this paper was assembled incidental to a study of social adjustment in old age made by the writer as Research Associate for the Subcommittee on Social Adjustment in Old Age of the Social Science Research Council; additional material was secured by four senior students at Rockford College: Barbara Conklin, Joyce Gayle, Susan Eckels, and Elizabeth Siegfried.

[2] Bureau of the Census, Population—Special Reports: Series P-46, No. 7. September 15, 1946.

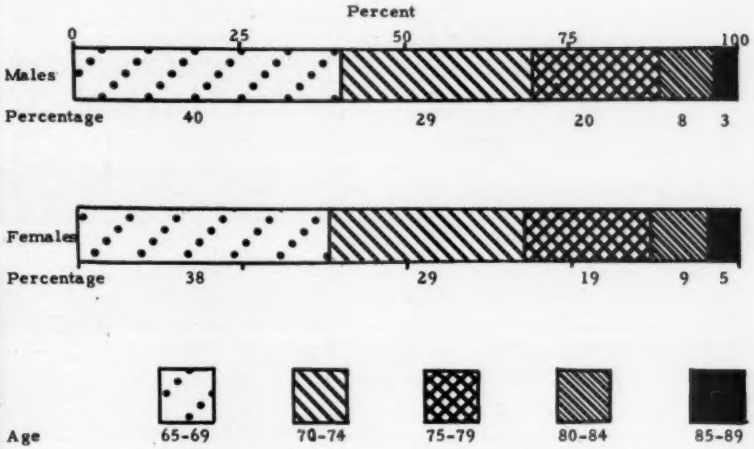

FIG. 1.—Percentage distribution of males and females aged 65 and over, by five year periods, for Rockford, Illinois, 1940. Based on Sixteenth Census of the United States, 1940, *Population*, Vol. IV. Part II, p. 614.

sent an aging group. The Negroes came in primarily at the time of the first world war as young workers who have not reached old age. Any program which penalized foreign-born people would work a great hardship on almost half the old people in the community. Also any program that overlooked the characteristic cultural, religious, and language patterns of the dominant foreign-born groups would fail of its purpose.

Although we tend to group everyone who is 65 and over into one category called old age, it is important to realize that actually this group has an age span that runs from 65 to 100 or 35 years. Two-fifths of the old people are between the ages of 65 and 69, that is, they are little different from the group that we think of as middle-aged. Many of them are still employed. We do not have the employment status by age groups for Rockford, but for the United States in 1940, 52.0 percent of the men and 8.6 percent of the women between ages 65 and 69 were employed. Twenty-nine percent of the old age group is aged 70-74 and of this group for the United States 35.4 percent of the men and 4.7 percent of the women are employed. One-fifth of the old age group is between 75 and 79 years of age, and the proportion employed has decreased greatly. Less than ten percent of the old age group is between 80 and 84 years of age and less than 5 percent over 85 (fig. 1). About one-third of all old people must therefore be thought of as able-bodied, employed, and independent. More than half are still reasonably active. The proportion that may be termed aged and that is in need of protective personal care as well as economic assistance is relatively small. Plans for housing, physical

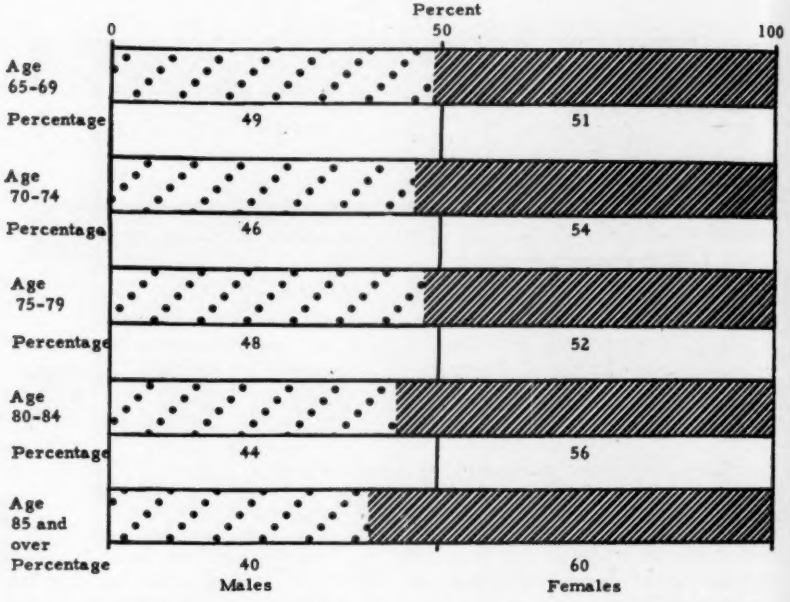

FIG. 2.—Percentage of males and females by age periods for Rockford, Illinois, 1940. Based on Sixteenth Census of the United States, 1940, *Population*, Vol. IV, Part II, p. 626.

care, recreation, and occupation should include a gradation that runs from facilities suitable to completely able and independent people to facilities for those who are physically and mentally helpless. Any one program would serve only a portion of the old age group.

The old age group is unevenly divided between the sexes with women in the majority. For the total old age group there are 12 percent more women than men. Because the death rate is higher for men than for women, with each succeeding year the ratio of women to men becomes greater. At age 65-69 women are only slightly in excess of men. In Rockford at this age women constitute 51 percent of the group. By the time age 85 and over is reached, women constitute 60 per cent of the group (fig. 2). Aged women therefore represent a special group.

Although the death rate is higher for old men than for old women, it is high for both groups and these two facts combined create a very large number of widows and widowers, but especially of widows. As early as age 65-69, 41.7 percent of all women are widows as compared with 16.6 percent of men who are widowers. The proportion of both widows and widowers increases rapidly until, for age 85 and over, 84.9 percent of all women and 65.3 percent of all men are widowed (fig. 3). It is probable that some of those included with the married have been widowed

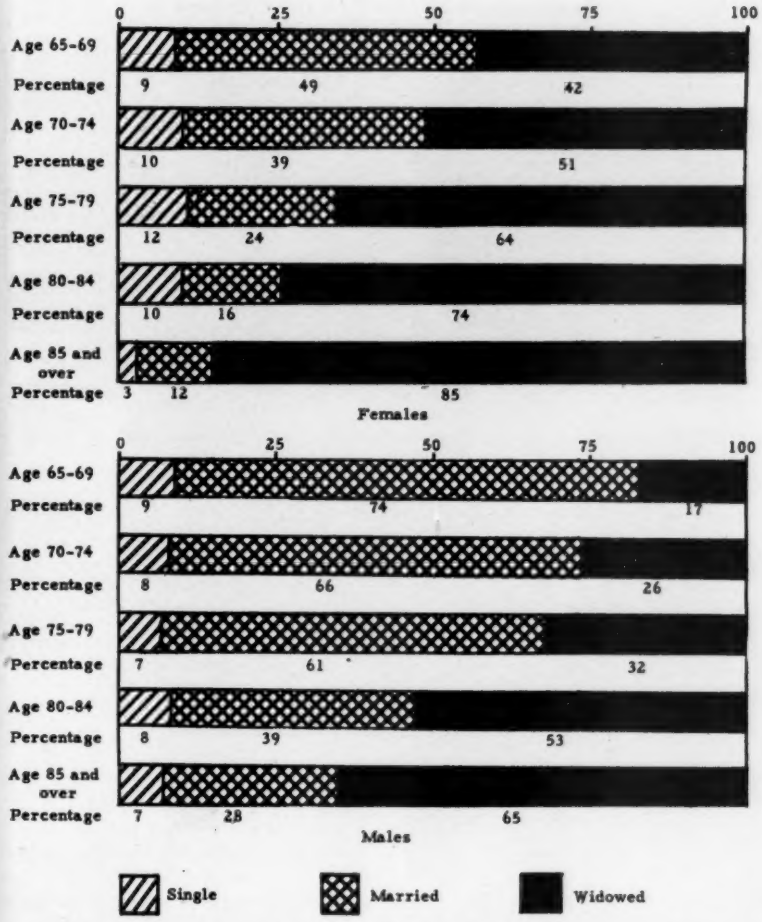

FIG. 3.—Percentage distribution by marital status for males and females according to age periods for Rockford, Illinois, 1940. Because of the small number, divorces and separations are omitted. Based on Sixteenth Census of the United States, *Population*, Vol. IV, Part II, p. 620.

during old age but have remarried. This statement applies especially to the men, who find remarriage simpler than do old women, and who often marry persons not included in the old age group. When these figures are interpreted in human qualities, we are forced to think of old age as a period of increasing family disintegration through death of the husband or wife and therefore of loneliness, detachment from intimate family groups, and often the breakup of the family home and the

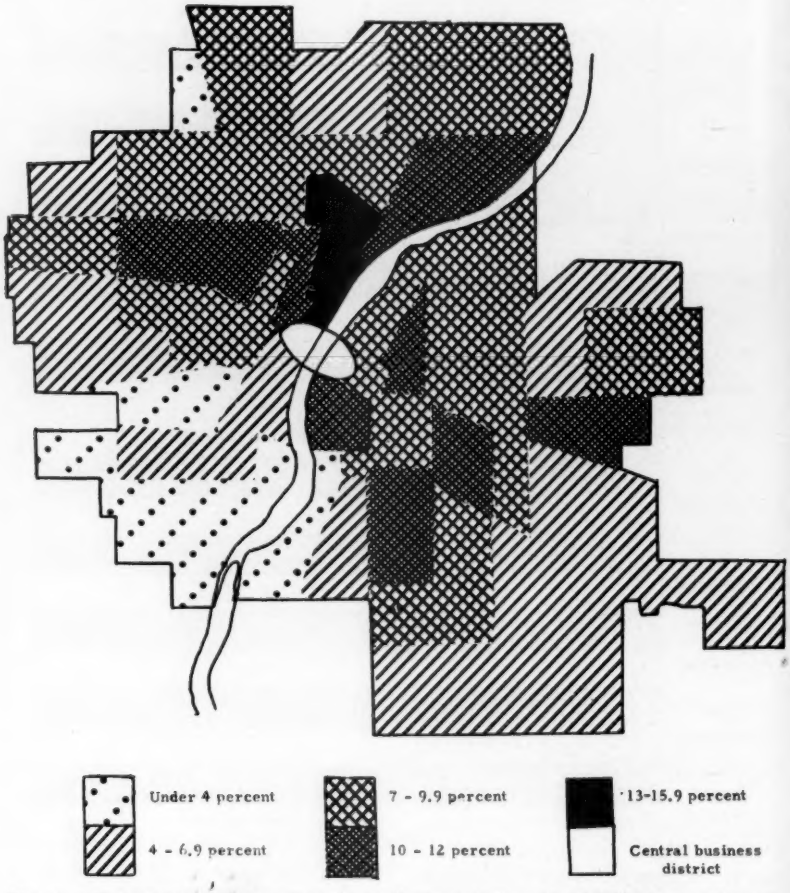

FIG. 4.—Percentage of the women in each enumeration district that was 65 years of age or older, Rockford, Illinois, 1940. Data from the Bureau of Census.

necessity of adjustment to new living arrangements.

Age 65 is coming to be accepted as the time for people to retire from active employment. Retirement usually means lowered income and often a state of complete dependency either upon public agencies or upon adult children. The sources of support for old people in Rockford can only be estimated. About 13 percent of the group receives state Old-age Pensions, averaging $41 per month; about 25 percent receives payments under Social Security benefits, averaging about $26 per month. Small groups of policemen, firemen, postal employees, and teachers receive pensions. Few of the industries have pension plans, although some are in-

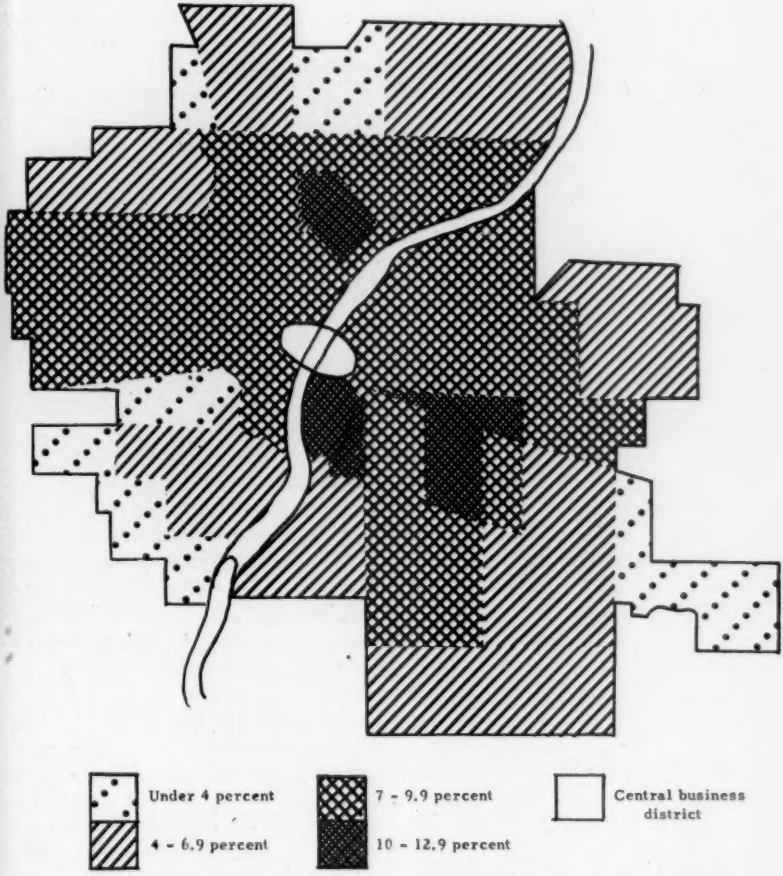

FIG. 5.—Percentage of men in each enumeration district that was 65 years of age or older, Rockford, Illinois, 1940. Data from the Bureau of Census.

augurating them. It seems to be a reasonable estimate that more than half of the old people are supported by their own earnings, savings, or their adult children. For many old people the entrance upon old age means the loss of economic security, lowered socio-economic status, movement to cramped living quarters, and drastic curtailment of social activities. Adjustment to these changes may be as serious as adjustment to the death of husband or wife. When for an elderly woman, the death of the husband coincides with loss of income, she may face adjustment to both loneliness and lower socio-economic status at the same time.

Although health figures are not available for Rockford, we know

from general information and the National Health Survey that old people suffer from more illness than do younger people and also are subject to many chronic diseases and physical defects. On the average, persons 65 years of age and over suffer about five weeks of disabling illness per year.[3] Chronic diseases and physical handicaps include arthritis, high blood pressure, heart disease, arteriosclerosis, failing sight and hearing, and general physical enfeeblement. All these handicaps in some way limit activity and participation in social activities; many of them cause recurrent or chronic pain; and some of them make the person bedfast or otherwise totally dependent upon others for physical care. Any plan for the care of the old or for occupations and recreation must be adjusted to different types and different degrees of physical disability.

Although there are no communities composed solely of old people in the city of Rockford, neither are old people distributed evenly throughout the population. Maps were made to show the percentage of old people in each enumeration district used for the Census of 1940 (figs. 4 and 5). The communities with the lowest percentages of old people are on the outskirts of the city and in the suburbs. One area with a population of 167 people has only one old person. An area with 1217 has only 49 old people. In many only 3 or 4 percent are 65 or older. These are the communities most recently settled and into them have moved young couples with children. The old people constitute a higher percentage of the population in the areas near the business center of the city. A few of these areas have as high as 12 or 13 percent of the population who are 65 or older. These areas are the old part of the city. In the better class old areas old people live in homes which they have lived in and owned since their youth. Near the business center are also the rooms and flats over stores and the large homes converted into light housekeeping rooms where rents are low. Into these quarters move the old people whose income is low. Three or four families may share one bathroom and many of the old houses do not have central heating. Some of the old people who have never had a high standard of living are content and happy; for others who at one time lived comfortably but now have a small income the change has brought bitterness and resentment. Other old people live in hotels or in rooming houses near the center of the city, where they are conveniently near restaurants, stores, and motion picture houses. Rockford requires an inspection by the Health Department of all rooming houses which cater to six or more roomers. There are ninety rooming houses in Rockford, most of them within two-thirds of a mile of the central business district. Not all of these rooming houses serve old people, but some include a few old people and others are operated especially for them, with the landladies providing meals as well as rooms and a certain amount of care in case of illness. Some of these rooming houses and boarding homes that cater to the old charge as much

[3] National Resources Planning Board, Human Conservation, the Story of our Wasted Resources: Government Printing Office, Washington, D. C., 1943, pp. 92-93.

as $125 per month; others will accept the amount received by old-age pensioners, averaging $41 per month. The old people who are scattered throughout the residential districts live in their own homes, with their children, or in private families that take only one or two roomers and hence are not included in the official list of rooming houses with six or more roomers.

The problem of housing for old people is revealed only partly by a study of the communities where they tend to congregate. The prevalence of chronic illness among old people has been mentioned. Chronic illness and the general enfeeblement that comes with advanced years create a special housing problem, for here is a group unable to live independently and at the same time not sufficiently ill to become hospital patients. Some of these ailing old people are cared for by adult children; others have no children; in other cases the complications of adapting a normal family life to the demands of a chronic invalid have become so great that continued care in the home of a son or daughter threatens the integrity of the family. Finances are also a complication, because the income of those on Old-age Pensions is low even though the state makes additional grants to those in need of physical care. No comprehensive planned attempt has been made in Rockford to provide for old chronic invalids. Nevertheless, various institutions have developed out of the evident need, or already existing institutions have adapted themselves to some degree to provision for chronic invalids. The institutions that help to meet the need fall into five types.

1. The County Farm does not limit its service to old people, but the old constitute most of the clients. The County Farm has four divisions. The division known as the Farm Home houses 45 people, including old people who have not yet reached the age of 65 when they are eligible for Old-age Pensions and those who for some other reason are not eligible. A convalescent ward cares for 42 people and there is a plan to increase the capacity to 100; this ward is planned for the chronically ill and caters for the most part to the old. There is also a hospital which can give care to 65 acutely ill persons; these are not all old. A small contagious ward is also operated in connection with the County Farm, but we are not concerned with this ward as few old people contract contagious diseases. When anyone enters the County Farm he must be a client of township relief; this means that when an old-age pensioner enters he gives up his pension from the State. When married couples enter the Farm Home they are placed in separate men's and women's wards.

There is some agitation in the community to induce the county board of supervisors to convert the Farm Home into a home for chronic invalids, most of whom of course would be old people. The State of Illinois now makes provision for county farms to convert to hospitals for chronic cases and receive payment for their clients from Old-age Pension funds of the State. The county must bring the physical equipment and personnel of the in-

stitution up to a given standard and meet certain standards of care. The State then pays a sum previously agreed upon for each old-age pensioner who finds it necessary to enter the institution. At present when old people on pensions enter the Farm Home they become clients of township relief. In some counties the county farms had closed when their clients left to receive pensions and live independently. The effect of the law was to induce counties to re-open their county farms and to modernize them. The Winnebago County Farm did not close and is now handling as many persons as it can. If a conversion was made the effect would be to provide care for more chronically ill and to assure a larger proportion of the income of the Farm from the state pension funds rather than from township funds. At the same time, other provisions might have to be made for any persons in the Farm Home not chronically ill or not eligible for the State Old-age Pension.

2. The second type of institution serving chronically ill old people is the private nursing home. These homes are operated as a business venture by women who make a living by caring for old people. There are at least six such nursing homes in Rockford, located in large old houses. A local ordinance provides for inspection of these nursing homes by the Health Department. The inspection covers all types of sanitation, lighting, ventilation, heating, care of food, number and types of nurses, and records kept. Fire safety provisions must also be met. It is extremely difficult for most of these nursing homes to meet the requirements and at the same time keep the fees charged low enough to make it possible to give care to the low income group. There is a tendency to subdivide rooms sometimes only by partitions which run part way to the ceiling and to place several persons in one room. The operators of some of the homes meet criticism of the physical aspects by calling attention to the limited needs of the old and by emphasizing the response of their patients to sympathetic personal care. A few of the nursing homes charge higher fees and have more adequate facilities.

3. There is one small private hospital whose patients are mostly old persons who are chronic invalids. This hospital is organized as a non-profit institution and caters to about 25 people. Standards are high and it is well administered.

4. The fourth type of institution does not specifically solicit chronically ill persons but by nature of the service given provides for many who are chronically ill. There are three privately financed institutional Homes in Rockford caring for a total of about 150 persons, not all from Rockford, however, as the largest of the three Homes serves the entire state. Each of these Homes has its own entrance requirements. One serves only those affiliated with a lodge; another only those of one nationality background; two have entrance fees. All three require that the resident be in good health at the time of entrance; but once accepted the resident is assured of adequate care through whatever illness may develop. Hence these Homes have a number of chronic invalids.

Very few of the residents of these Homes are men and none are married couples.

5. The fifth type of institution that serves the chronically ill old person is the general or special hospital which serves all classes of the population, the old included. Rockford has three general hospitals, a private mental hospital, and a municipal tuberculosis sanitarium. Each of these institutions has its quota of the old, and although the general hospitals dislike to take chronic cases because of the demand for facilities for acute cases they are not always able to avoid it.

As we put together the various bits of information on housing and correlate them with the types of old people in the population, the two most acute needs not well met are sufficient care for the chronically ill and feeble old persons, and better provision for those still able to carry on alone but who are on Old-age Pensions or have other small incomes not large enough to provide comfortable living quarters. There is also need for better provision for old couples. The classes of old people best provided for in the matter of housing are those with adequate private incomes, those cared for by their adult children, and those in institutional Homes.

Old people typically have more time than they know how to fill satisfactorily. Old men especially, after retirement, have unfilled days. Old women are in a similar position if they have been employed, if they enter a Home for the old, and often if they become members of a son's or daughter's household. The situation is complicated by the lowered income of many of these people after retirement and also by decreasing strength which makes an expansion of activities difficult. The typical picture is of the old person sitting around or aimlessly puttering at almost useless jobs or restlessly getting into other people's way in trying to help. As age increases, it becomes more difficult for the old person to travel about the city alone, and he drops first one type of contact and then another. If he cannot afford to pay dues or put money in the collection plate at church he drops out of organized groups soon after retirement. The need for activities is not met in any definite manner in Rockford—in fact it is scarcely recognized as a need. Some community agencies more or less incidentally supply old people with occupations. This situation is true of the Goodwill Industries, whose function is to rehabilitate handicapped workers. At least during the war period when private employment was plentiful, most of their workers were over 60 years old. In a period of industrial expansion, as during the war, many industries employed old people, although none of the industries where interviews were held had a policy of employing old people. Some of the industries give recognition at company dinners to employees who have been with the company for long periods of time. After retirement securing of paid employment is a matter for individual effort—no agency takes the initiative in helping old people find jobs. Likewise, no agency was found that definitely had a plan for helping old people find unpaid occupations. Four enterprising old men regularly gave

volunteer work to the ration board during the war, but the initiative came from one of the old men who volunteered his services and brought in three friends. A sampling of churches did not reveal any effort to provide organizations for old people, although some churches more or less incidentally had organized activities that appealed to old people. In one church, for instance, a thriving Red Cross sewing group provides both productive work and a social outlet for a group of elderly and old women, but it was not begun with the idea that it would appeal to these women. There are no specifically old-age clubs, such as the Borrowed-Time Clubs or Three-quarter Century Clubs found in some cities. Retired teachers have a club. Other old people are in clubs which they, as young persons, organized and which now are old people's clubs by virtue of the passage of time and the failure to take in new and younger members. The settlements and community houses in the city have no special activities for the old, although the old are able to participate if they wish in the general activities for adults. Also the lodges, and men's and women's clubs and civic or social organizations have their contingent of members who have grown old. Although one often hears it said that old people should not be herded together into groups but should participate with younger people, nevertheless we also have to recognize that often they are pushed aside in younger groups and have no opportunity to serve as officers, on committees, or actively in providing programs. In their own organizations they may set their own pace and exercise initiative and authority. It seems that some of the outlets of old people should cater specifically to their interests and be limited to their abilities.

For those who live into the later years and for many with chronic handicaps different types of occupation and recreation are needed—those that can be brought to the old person at home or which can be carried out in the immediate neighborhood. There is no provision for such activities on a community basis. The nursing homes and institutional Homes do very little, although most of them provide for holidays, birthdays, and other special occasions. Sometimes groups from the community go in to sing or entertain. While this type of effort provides entertainment or amusement it is not of the type to give the old person the satisfaction of participating in an activity himself, or creating or producing something. In the institutions that were visited (several of them a number of times) the old people seemed to spend most of their time in their own rooms, behind closed doors, listening to the radio, reading, or in other solitary pursuits. This isolation was not because of any pressure from those in charge of the institutions. It arose in part because of a desire for quiet, but also because of a lack of provision for interesting group activities. In time, old people become habituated to isolation and solitary activities and develop ingrown and egotistical personalities which make it difficult for them to maintain satisfactory social contacts.

The problem of participation in groups outside the house is acute for

many old people. In one Home many old people were housebound unless someone called for them in a car or a matron took them in a car as the Home is several blocks from the bus line and there is no sidewalk. Even the residents of a Home near the center of the city were housebound in winter unless some friend came for them, because they feared to venture on the icy sidewalks. Those in their own homes may also be isolated. One woman whose foot dragged because of a stroke several years before had not been out of her basement apartment for five months during the winter because she was afraid she would fall on the slippery walks. Her only human contact was the daily one with a dull and slightly demented husband.

A less obvious need of old people in Rockford as elsewhere, is for intimate companionship and affection. As physical strength declines, self-confidence also declines, and the need for a protective love increases. The assurance of physical care relieves many of the anxieties of old people, but it does not take the place of personal affection. The old couple is most happily situated for each has the companion of many years standing, to love and be loved by, to quarrel with and to make up with, each understanding the peculiarities and appreciating the good qualities of the other. When the old person is left as a widow or widower the first thought of family, friends, and community agencies is to provide good physical care. The conception of good physical care held by a younger member of the family or by the community may involve moving the old person from his home and perhaps from his neighborhood or city. This involves still further loss of intimate relationship, for the old person is then separated from his friends. If the old person becomes a member of the household of a married son or daughter, he may find a family circle that is complete without him and he may never feel completely a member of the family. There are times when it is better for an old person to move in with another companionable old person or into an institution than to live with a son or daughter but not be a member of the family circle. The old person will at least find someone of his own age in the partnership with another old person or in the institution, and he will expect less affection than from his own family and therefore feel less tension if relationships remain on an impersonal basis. As people become very old and more helpless it is important for them to have a sympathetic, somewhat younger person to whom to cling who will give assurance of continued loving care. This person may be a member of the family, or may be a nurse or attendant. The loneliness and detachment of old people are greater in a city than in small towns, for there is less neighborliness and therefore less concern of people for one another.

Finally, we come to a consideration of the personal happiness of old people and the personal disorganization which may result when unhappiness is long continued and there is no prospect of future happiness. Drastic changes normally cause some disorganization and unadjustment at whatever age they come. When the child first enters kindergarten, when the adolescent becomes a col-

lege student, when the youth secures his first job, when the young adult marries, there is a period of uncertainty and doubt. But usually these changes have prospects of increased pleasures to offset the temporary disturbance. Deaths, unemployment, illnesses, disappointments in love and in ambitions come also to the young; but again they may be offset by other values or they may disturb only one area rather than many areas of life. And the young look into the future and adjust to the difficulties of the present. The old person is in a different situation. In the first place, many of the changes are permanent in character: retirement is permanent unemployment; illnesses are likely to be chronic rather than brief; widowhood holds little future promise of remarriage. In the second place, the changes of old age are likely to be cumulative: retirement means lowered income, which in turn means lowered social status and a giving up of many activities and luxuries; or death of a husband means not only loneliness but loss of income and perhaps the inability of the old widow to continue in her own home. Even when changes are not related to each other, they seem to come to the old with only brief intervals between. The person over 65 must accept the prospect of unemployment, lowered income, deaths of family and friends, decreased vitality, and increased and perhaps chronic illnesses. These many and drastic changes that come to the old are not offset by the prospect of future gains. In general the world of the old is a contracting one with an ever shortening and more dreary future. It is not surprising therefore that many old people are irritable, quarrelsome, and inclined to criticise others for their unhappiness; or that others are self-centered and take refuge in pains and aches or try to dominate those about them; or that others are torn by fears and anxieties beyond any reasonable degree. In our contacts with old people in Rockford, these and other symptoms of unhappiness and maladjustment were found. A few cities in the United States have established consultation centers for old people, where old people or those concerned for their welfare may go to talk over their problems and receive advice as to special agencies that may help them. Rockford does not have such a center, although there is some tendency for people to go for general advice to the staff of the Division of Public Assistance, which administers Old-age Pensions, as well as to make applications for pensions. The policewomen of Rockford also find that old people, men and women, come to them for advice and reassurance, especially when they feel that someone is imposing upon them. Some ministers attempt to keep in touch with old people even after they are no longer able to attend church. But other ministers center their attention upon the young and are blind to the needs of the old; and some ministers who call upon the old have developed techniques for keeping their calls short and formal, thus forestalling the flood of repressed grievances that might pour forth. The social agencies proper, that are concerned with personal and social adjustment, tend to concentrate their attention upon the young, for in them they see the

threat to future community welfare and the prospect of improvement. The experience in other cities has shown that many old people may be helped both to find more satisfactory living arrangements and activities and thus decrease their dissatisfactions and to readjust their attitudes toward themselves and others so that they will more gracefully accept the increasing limitations of old age. It is true, of course, that some of the old who are unadjusted cannot be helped. Senile dementia claims some of the old. In Rockford, as in most communities, serious cases of senile dementia find their way to the state asylums, and mildly disturbed people are accepted in some of the local nursing homes. What is not clearly understood is that there is a wide twilight zone between well developed senile dementia and normality, a zone of unhappy and slightly disturbed old people whose problems might be solved by reorganizing their activities and helping them to readjust their attitudes.

In conclusion, the conditions and problems of old people in Rockford (and in other cities) may be listed:

1. In 1940, persons aged 65 and over equalled 7.6 percent of the population of the city and 7.0 percent of the suburban population.

2. The proportion of the old that is foreign-born is three times the proportion in the general population that is foreign born.

3. The foreign-born equal 45 percent of all old people: Negroes represent only 0.7 percent of the old.

4. Old age, running from 65 to 100 years, is a long period. The younger group in general is able-bodied, active, and often employed; the middle group usually is not employed and has reached a period of limited activity; a small, older group requires personal care.

5. Women exceed men, especially in the older age brackets. For age 85 and over, 60 percent of the group are women.

6. Widows and widowers become an increasing proportion of the old age group with each five-year period. For the oldest group, aged 85 and over, 84.9 percent of all women and 65.3 percent of all men are widowed.

7. Sixty-five is coming to be accepted as the age for retirement, although in a prosperous period such as the war period, many work until age 70 or even longer. Retirement brings problems of support. In Rockford about 13 percent receive Old-age Pensions and about 25 percent receive Social Security benefits. Others continue to work, live on their savings, receive pensions as public or industrial employees, or are supported by their sons and daughters. The number falling into these classes is not known.

8. The amount of ill health and the number of serious physical handicaps are not known but surveys in other communities indicate that physical disabilities of all kinds are common among old people.

9. Old people in Rockford tend to congregate more heavily in areas near the business center than in outlying communities. Some live in comfortable homes but others are living in rooming houses, light-housekeeping rooms, or hotels.

10. The chronically ill present a special problem of housing and care. Rockford has a variety of facilities but is inadequately prepared to care

for the feeble and chronically ill with low incomes. The provisions include the County Farm Home and the convalescent ward of the County Hospital, one small private hospital that caters to the old, a half dozen private nursing homes with varying fees, and the facilities of the hospitals that serve all classes of the community. Institutional Homes care for about 150 old people, some of whom have become physically disabled after entering the Homes.

11. Among all types of institutional care little provision is made for old couples, who find themselves either not accepted in the institutions or are compelled to live in separate men's and women's wards.

12. Old people are left to find occupations and recreation as best they can, either in clubs and organizations to which they have belonged since earlier years or in activities not planned especially for the old but which happen to appeal to them. Almost no attention is given in the community to old people who are unable on their own initiative to find satisfying activities.

13. Many old people are unable to leave their homes or immediate neighborhoods. Unless families or friends are able to take them out they spend weeks and perhaps months without outside contacts.

14. Many old people are unable to adjust without aid to the many changes that come in old age and to the prospect of continued ill health and restrictions in activities. Although various community agencies give these old people some guidance there is no agency that accepts this work as a special function.

15. Finally, the problems of the old in Rockford are probably the problems of the old in any small industrial city; its facilities for their care are probably equal to facilities elsewhere; and its slow awakening to the needs of the old is no doubt typical of many communities.

A BASIC DEFECT IN THE ILLINOIS CONSTITUTION

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The government of the State of Illinois is today functioning under a constitution adopted in 1870. In spite of eight amendments, the last of which was adopted in 1908, there has been an increasing amount of dissatisfaction with our State Constitution. The recognition of the need for far-reaching and numerous changes had become so widespread that in 1920 a constitutional convention was called. The fact that the results of that convention were not approved by a majority of the voters at a special election called in 1922 does not mean that the need for change has diminished. On the contrary, the inadequacies of the present Constitution have become increasingly apparent as the years have passed.

It is not my intention here to make any item by item analysis of the present Constitution, nor to propose specific changes in the various articles. Many analyses have already been made of specific aspects of that Constitution, pointing to defects in such matters as the amending procedure, the judicial organization of the State, the revenue system, the organization of the executive branch of the State government, and the provisions for local government. Rather than to repeat those analyses—a repetition which could only be superficial in a brief address—I wish to call your attention, in this paper, to what I consider to be a basic defect of the Illinois Constitution. The point I should like to make might be introduced by the question: Why should the present Constitution be so thoroughly criticized, so generally unsatisfactory in so many of its provisions, unless there be some basic defect?

Much that has been written and said on behalf of a need for constitutional revision in Illinois implies that the basic defect is the age of the present Constitution. It is easy to point to the fact that the Constitution was adopted seventy-seven long years ago, and that it was intended to operate in an agricultural state populated by a meager two and a half million instead of in an industrialized state with a population approaching eight million. And now we have the atom bomb to make the contrast even more striking. All of these points are true, but I think it is gross error to assume, without further inquiry, that a constitution is inadequate, out-dated, and defective merely because it was drafted and adopted with reference to economic, social, and political conditions which have since undergone fundamental changes.

Let us for a moment make some comparisons between the Illinois and United States Constitutions. If one is old, the other is much older. Seventy-seven years is young contrasted to the one hundred and fifty-eight year age of the Constitution of the United States. While the population increase during the life of the Illinois Constitution has been threefold, the population increase during the life of the Federal Constitution

has been almost fifty-fold, or from three to one hundred and forty million. And need I do more than to hint at the far greater economic, social and political changes that have taken place in the United States in the last 158 years than have developed in the state of Illinois in the past 77 years? In spite of these contrasts the Federal Constitution has been better adapted to modern problems than has the Illinois Constitution. One cannot justifiably say that this better adaptability is due to the character or greater number of amendments to the Federal Constitution. While it is true that there are technically twenty-one amendments to the Federal Constitution as against only eight to the Illinois Constitution, yet it must be realized that only a few of the twenty-one amendments have any significant bearing on the problem of adjusting the Federal Constitution to changing economic, social and political conditions. For our purposes here the first ten amendments may be disregarded because they were adopted in the early 1790's under circumstances which indicate that the people of those times considered them an integral part of the original Constitution. Of the remaining eleven amendments only five can be regarded as having been prompted or necessitated by economic or social changes. These five are the three civil war amendments, the 16th amendment which cleared away an obstacle to the adoption of an income tax by the Federal Government, and the 19th amendment which extended the suffrage to women. But the subjects of these amendments involve only a microscopic few of the many phases of American life which have undergone great change. It is safe to conclude that the amendments to the Federal Constitution have contributed only slightly to the great task of adapting that Constitution to modern conditions.

The comparison I have been making ought to demonstrate amply that the mere age of a constitution is not in and of itself a defect. The comparison hints, furthermore, at what I regard as a fundamental defect of the present Illinois Constitution. That defect is that the Constitution is too long and too rigid. The Illinois Constitution is not flexible and adaptable to changing conditions. In that respect it differs greatly from the Federal Constitution. It should be emphatically noted that a well drafted constitution will contain no more than the bare essentials, the fundamental features, with respect to the organization and powers of the government to be established. Further than the fundamentals it should not go. Therein lies a vital defect of the Illinois Constitution. It contains more than the bare essentials. It contains much that is properly of a legislative level, not of constitutional importance. It is not without significance that whereas the Federal Constitution as amended contains roughly 7,500 words, the Illinois Constitution requires approximately 25,000 words.

A few illustrations will demonstrate the defect I am describing. Article XIII, which deals with public warehouses, provides in section 2 that:

> The owner, lessee or manager of each and every public warehouse situated in any town or city of not less than 100,000 inhabitants, shall make weekly statements under oath, before some officer

to be designated by law, and keep the same posted in some conspicuous place in the office of such warehouse, and shall also file a copy for public examination in such place as shall be designated by law, which statement shall correctly set forth the amount and grade of each and every kind of grain in such warehouse, together with such other property as may be stored therein, and what warehouse receipts have been issued, and are, at the time of making such statement, outstanding therefor; and shall, on the copy posted in the warehouse, note daily such changes as may be made in the quantity and grade of grain in such warehouse; and the different grades of grain shipped in separate lots shall not be mixed with inferior or superior grades without the consent of the owner or consignee thereof.

Notice the unnecessary rigidity of this section. And subsequent sections of the same article contain provisions equally definitive. Such details have no place in a constitution. They are essentially legislative, not constitutional in character. It is not, I submit, basically essential for the effective and satisfactory functioning of government in Illinois that the provisions of this article apply only to cities with more than a 100,000 population; nor that statements under oath be made every seven days; nor that daily changes be noted. Such specific requirements in a constitution prevent the legislature from adjusting the operations of the government to meet the main purpose of the article. The objective was to prevent the issuance of false and fraudulent warehouse receipts and to protect producers and shippers from such falsification and fraud. Yet from the way in which the article was drafted with all its detail the legislature could not without constitutional amendment have extended like control to prevent fraud on the part of the operators of public warehouses in cities with a population under 100,000. Also, without further amendment the state legislature could not properly provide for quarterly instead of weekly statements from public warehouse operators even though it were realized that weekly statements were u n d u l y burdensome on business and unnecessary for the purpose of the regulation. A person would seriously be considered a fit inmate for an insane asylum were he to propose that the Federal Constitution be amended so as to provide for a bi-weekly report to the Interstate Commerce Commission of the total volume of business done by all common carriers engaged in interstate commerce.

Criticism of a similar nature may be made of provisions in the Illinois Constitution on the subject of local government. Every county in the State is constitutionally required to elect a county judge, a county clerk, a sheriff, a treasurer, a coroner, and a clerk of the circuit court. In addition those counties which have not chosen to organize on a township basis are required to elect a board of three members to be known as the Board of County Commissioners, part of whose authority is defined in the constitution. In addition the management of the county affairs of Cook County are constitutionally vested in a board of fifteen, two-thirds of the board to come from within and one-third to come from without the city of Chicago. It should be obvious that provisions such as these prevent the legislature and the people of Illinois counties from taking full advantage of the experience and experiments of other

states in the matter of improved county organization. In New York City and some other jurisdictions, for example, it has been found that a Chief Medical Examiner who is appointed and under civil service is far more satisfactory than the ancient office of Coroner, which it has replaced. In order for an Illinois county to profit by that experience it would first be necessary to eliminate the elective office of the coroner by a constitutional amendment.

One further illustration of constitutional rigidity in Illinois may be noted in the constitutional requirement that in the executive branch of the State government the following officers must be elected: the Governor, the Lieutenant Governor, the Secretary of State, the Attorney General, the Treasurer, the Auditor of Public Accounts, and the Superintendent of Public Instruction. This election system means that these officers are in an autonomous position, they may feel themselves responsible to none but the electorate for the operation of their respective departments. This situation permits these officers to direct their departments with a high degree of independence of the Governor, and can even lead to their working at cross purposes with the Governor. 'Such a condition of non-coordination has existed at times in Illinois to the serious jeopardy of the effective functioning of the State government. Any attempt to remedy it requires a constitutional amendment. It is interesting, in this respect, to note that in 1917 the State of Illinois took the lead in the re-organization of its executive branch. This re-organization took the form of eliminating the autonomous position of many of the existing departments, boards and commissions by bringing them under the guiding and co-ordinating authority of the Governor. It was a governmental improvement that was long overdue in practically every state in the Union. However, the much needed coordination of the executive branch in Illinois had to stop short of the goal desired by some because the legislature was not free to alter the constitutional autonomy of the Attorney General, the Secretary of State, and the few others.

For those who wish to take the time to study the Constitution of Illinois other illustrations than those given above could be found which reveal the tendency of the Constitution to go too much into detail—the unhealthy tendency to clothe matters which properly belong to the level of legislative policy with the rigidity and sanctity of a constitutional status. The adaptability of the government to changing conditions is thus seriously jeopardized. No good executive, whether he be a business man or a public official, would delegate duties to a subordinate and specify in detail the manner in which those duties were to be carried out. He would content himself with outlining the general purpose of the authority he was delegating and leave it up to the subordinate to determine and alter, if necessary from time to time, the means by which that authority was to be implemented. One might legitimately wonder why we don't use the same principles when acting in our sovereign capacity as when acting as good business men.

Unless the present inflexibility of

the Illinois constitution is corrected many of its defective articles will not be satisfactorily remedied. A revised constitution as inflexible as the present one would provide only a temporary improvement. Defects in such a revised constitution would quickly develop as the need arose for changing details. The benefits of a brief and flexible constitution can nowhere be found better revealed than in our own Federal Constitution. The contrast between the Federal and Illinois constitutions in the manner in which many important matters are handled is striking. Whereas the Illinois Constitution in Article VI devotes many hundreds of words to a description of a court system for the state, the Federal Constitution dismisses the subject of the structure of the Federal court system with the following brevity:

> The judicial power of the United States shall be vested in one Supreme Court and such inferior courts as Congress shall from time to time ordain and establish.

If the subject matter of Article XIII of the Illinois Constitution had been handled in the manner used in the Federal Constitution for granting legislative power it would have been condensed to some wording such as this:

> In order to prevent the issue of false and fraudulent warehouse receipts and to protect producers and shippers the Legislature shall have the authority to pass all laws necessary for the regulation of elevators or storehouses where grain or other property is stored for a compensation.

If the powers of Congress over such subjects as interstate commerce, of bankruptcy and coinage of money had been as carefully and thoroughly described as was the power of the state legislature over warehouses the Federal Constitution would have necessitated endless amendments beginning within a few decades of its adoption. In the Federal Constitution the only executive officers named are the President and the Vice President. The departments of the executive branch of our national government have been allowed to develop as the times required. At least in their development Congress has not been hampered by the notions which the framers of the Constitution had in 1787 as regards the number and duties of these departments.

The remarks I have been making on the matter of the essential nature of a constitution and the necessity for conforming to it were well summarized by John Marshall, one of the great Chief Justices of the United States Supreme Court, when he wrote in the important case of McCulloch v. Maryland:

> A constitution, to contain an accurate detail of all the subdivisions of which its great powers will admit, and of all the means by which they may be carried into execution, would partake of the prolixity of a legal code, and could scarcely be embraced by the human mind. It would probably never be understood by the public. Its nature, therefor, requires that only its great outlines should be marked, its important objects designated, and the minor ingredients which compose those objects be deduced from the nature of the objects themselves. That this idea was entertained by the framers of the American Constitution, is not only to be inferred from the nature of the instrument, but from the language.....We must never forget that it is a constitution we are expounding.[1]

And several pages later, in the same opinion, he observed that the American Constitution was

> intended to endure for ages to come, and, consequently, to be adapted to the vari-

[1] 4 Wheaton, 407.

ous crises of human affairs. To have prescribed the means by which government should, in all future time, execute its powers, would have been to change, entirely, the character of the instrument, and give it the properties of a legal code. It would have been an unwise attempt to provide, by immutable rules, for exigencies which, if foreseen at all, must have been seen dimly, and which can be best provided for as they occur.[2]

I sincerely believe that all efforts in Illinois for much needed constitutional improvement will be in vain unless the goal of the ideal constitution—a flexible constitution—is kept constantly in mind. But I would be guilty of leaving you with a gross misunderstanding were I to give you the impression that the task of casting constitutional provisions in broad and general terms while leaving it up to the legislature to fill in the details is an easy one. It is not. There are many opponents to constitutional revision. Their reasons for opposition are important and cannot be ignored. Broadly speaking these opponents fall into two groups. The first group is made up of those who have a personal interest in the preservation of one or more of the rigid provisions in the present Constitution. All people with high incomes and small real property holdings are in a personally advantageous position due to inability of the legislature under the present Constitution to levy a state income tax. They would certainly stand to lose if that position were disturbed. Coroners, whose office is now safeguarded by the Constitution, might well object to a revision which placed the very existence of their office at the hands of future legislatures. I do not wish to imply that all people who might conceivably fall within this first group will be swayed by an imagined personal interest, but there are a great many who will be. And unless this opposition is taken into account it may prove disastrous to reform.

The second group of opponents consists of those who fear that unless grants of power to our government are carefully defined and circumscribed our democratic institutions will be in serious danger at the hands of irresponsible officials who might not properly cherish our institutions. This group of citizens is undoubtedly motivated by a genuine desire to preserve democracy. No one has that desire more than I. But many people in this group are misguided as to how one best preserves democracy. It cannot be done by placing detailed checks on every grant of power. To do that is to defeat the very objective in establishing a government, for it leads to inactive government rather than democratic government. Democratic government cannot exist unless it is a competent government, and that means that grants of power must be ample and not too constricted. The fear of this is, of course, that broad grants of power may lead to abuse. But this is true of any grant of power. The only true protection against the abuse of power by our government lies in the selection of competent officials by an alert and intelligent electorate. In our desire to preserve democracy we must never overlook the fact that in spite of constitutional provisions the great principles of democracy will be maintained only as long as the people have faith in those principles and properly assume their responsibility at the ballot box.

[2] 4 Wheaton, 416.

ZOOLOGY

MILTON W. SANDERSON, *Chairman*
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* 1. The Influence of the Balcones Escarpment upon the Distribution of Amphibians and Reptiles of Central Texas: HOBART M. SMITH, University of Illinois, Urbana. (slides)

* 2. Internal Structure of the Epigynum in Primitive Spiders and its Bearing on Systematics: GILBERT WRIGHT, Illinois State Museum, Springfield. (slides)

3. A Concentration of Lemming Mice *(Synaptomys cooperi)* in Central Illinois: DONALD F. HOFFMEISTER, University of Illinois, Urbana. (slides)

4. Bird Population of an Illinois Floodplain Forest: BEN J. FAWVER, University of Illinois, Urbana. (slides)

* 5. Fish Population of Gale Lake, 18 Months after Severe Winter Mortality: GEORGE W. BENNETT, Illinois State Natural History Survey, Urbana. (slides)

6. Studies of the Sex Organs of Mating Polygyrid Landsnails: GLENN R. WEBB, University of Illinois, Urbana. (slides)

* 7. Animals of Eckert's Cave, Monroe County, Illinois: B. D. BURKS and L. J. STANNARD, Illinois State Natural History Survey, Urbana.

* 8. Quantitative Studies on the Amino Acids of Avian Erythrocytes: ROBERT M. MELAMPY, University of Illinois, Urbana. (slides)

9. Parasites of the Hylidae (Amphibia-Hylinae)—VI: A. C. WALTON, Knox College, Galesburg.

*10. Some Unusual Nuclei Found in the Acanthocephala: HARLEY J. VAN CLEAVE, University of Illinois, Urbana.

11. Major Fluctuations of Some Illinois Mammal Populations: CARL O. MOHR, Illinois State Natural History Survey, Urbana.

*12. Ecology, Taxonomy, and Distribution of *Elliptio complanatus* (Dillwyn) 1817, a Fresh-water Mussell: MAX R. MATTESON, University of Illinois, Urbana. (slides)

*13. Aerial Census and White-tailed Deer Research in Illinois: WILLET N. WANDELL, Illinois State Natural History Survey, Urbana. (slides)

14. The Grooming Dance and Associated Activities of the Honeybee Colony: VERN G. MILUM, University of Illinois, Urbana.

15. Notes and Additional Records of Mammals in Illinois: RALPH M. WETZEL, University of Illinois, Urbana.

16. An Investigation of Some Possible Sources of Trichina Infection in a Central Illinois Community: WAYNE W. WANTLAND and PAUL MARTIN, Illinois Wesleyan University, Bloomington.

*Not published.

BIRD POPULATION OF AN ILLINOIS FLOODPLAIN FOREST

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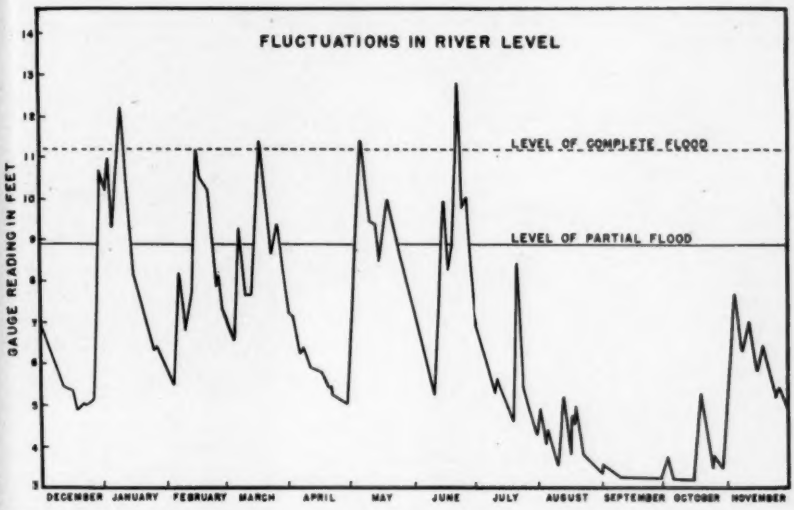
In recent years there has been considerable interest shown in the measurement of animal populations within ecological communities. Such quantitative information is of great service in evaluation of the importance of species within the community and of their habitat requirements. Forbes and Gross (1922) were among the first in this country to determine the bird population of various communities. In 1937, the National Audubon Society began an annual breeding bird census which has stimulated considerable work in this field. Kendeigh (1944) has summarized the history and discussed methods of bird censusing in a recent paper. With the usefulness of some of these newly developed techniques in mind, the floodplain forest was selected as an interesting community for investigation since its distinctive nature had been shown by Shelford (1913).

This paper is based on a study of the birds of a portion of the floodplain of the Sangamon River from March 10, 1946 to March 1, 1947. The area studied is one mile northwest of White Heath, Piatt County, Illinois and about fourteen miles due west of Champaign, Illinois. It lies in Sections 16 and 21 of Township 19 north, Range 6 east. An area of approximately fifty acres was selected for study and some observations were made for comparison over a mile length of the forested floodplain.

The area of study was ungrazed and evidently had not been cut over to any extent. The topography is nearly flat with elevations varying only about six feet. The numerous oxbows and sloughs which are filled with water most of the year account for this variation. According to the Monticello quadrangle of the U. S. Geological Survey, this section of the floodplain lies about 645 feet above sea-level. Since the floodplain is subject to frequent flooding the duff of the forest floor is scanty.

One of the outstanding factors of the physical environment of the floodplain is the periodic floods. The repeated occurrence of flooding is shown in the following graph. Gauge level data were obtained from the Urbana office of the Water Resources Branch, Geological Survey, U. S. Department of Interior. These gauge readings were taken at Monticello, Illinois, five miles downstream from the area of study. Flood levels were determined by observation of the dates of flooding of the study area. Frequently, river levels were high enough to flood only about half of this area and less often, the tract was totally flooded. This is shown in the graph by horizontal lines at these two levels. From December 1, 1945 to December 1, 1946, the area was totally flooded 15 days and partially flooded 28 days.

It is apparent from these data that the floodplain is a very moist environment. It is interesting to note


FLUCTUATIONS IN RIVER LEVEL
GAUGE READING IN FEET
LEVEL OF COMPLETE FLOOD
LEVEL OF PARTIAL FLOOD
DECEMBER JANUARY FEBRUARY MARCH APRIL MAY JUNE JULY AUGUST SEPTEMBER OCTOBER NOVEMBER

that the maximum river level was reached in the third week of June, a time of high nesting activity. Even during the periods of lowest water levels, some of the sloughs contained water and most of the year they all contained some water.

This floodplain forest is characterized by many small openings produced by fallen trees. The number of fallen dead trees, which produce dead stubs and openings in the canopy, is large. The frequent floods also kill much herbaceous growth and large areas are denuded of herbs because of standing water. Such bare portions represented roughly ten to fifteen percent of the area studied.

The composition of the tree canopy was determined by making four transects. Three transects were 3 meters wide and one was 6 meters wide, with the total length equaling 1127 meters. This amounted to 1.3 acres or 2.6 percent of the area. Although this is a rather inadequate sample, it is probably generally indicative. Measurements of the diameter of tree trunks over 2.5 inches were made at breast height with tree calipers. Table 1 shows the data obtained.

Climbing plants constitute a considerable part of the plant structure, both in species and in numbers (tables 3 and 4). These climbers make dense tangles in trees and shrubs as well as in the fallen trees. In openings in the canopy, giant ragweed grow up among the shrubs. Wood nettle is probably the most abundant species of herb in the shaded portions of the area.

Slippery elm and silver maple are the principal dominants of the floodplain (table 1). In drier portions the ironwood, yellowbud hickory, and bur oak form a prominent part of the canopy. Green ash, although not so numerous, forms a conspicuous part of the canopy because of

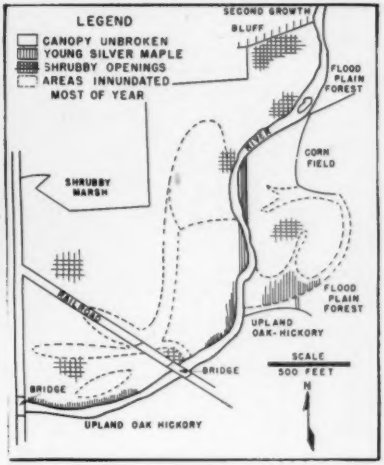
TABLE 1.—TREES IN VARIOUS SIZE CLASSES

Species	Trees per acre	Percent of individuals in diameter class (Diameter in inches)					
		2.5–6	6.1–12	12.1–18	18.1–24	24.0—	Total
Slippery elm	108	19.4	15.6	7.8	1.6	0.9	45.3
Silver maple	35	4.5	7.1	1.9	.....	1.0	14.5
Hackberry	28	9.7	1.6	.....	0.3	.....	11.6
Green ash	21	1.9	2.9	3.5	.....	0.3	8.6
Hawthorn	12	4.2	0.6	.....	.....	.....	4.8
Ironwood	9	2.9	0.6	0.6	0.3	.....	4.4
Yellowbud hickory	4	0.6	0.6	0.3	.....	.....	1.5
Sycamore	2	.....	.....	0.3	.....	0.6	0.9
Bur oak	2	.....	.....	0.3	.....	0.6	0.9
Lianas (Grape and poison ivy)	12	5.1	.....	.....	.....	.....	5.1
Miscellaneous species	3	0.7	.....	0.6	0.6	0.6	2.5
Total	236	49.0	28.9	15.3	2.8	4.0	

TABLE 2.—BREEDING BIRD POPULATION

Species	Number of pairs in the area	Density—number of pairs per 100 acres
Cardinal	9	14
Red-eyed vireo	7	12
American redstart	6	12
Indigo bunting	9	12
Wood pewee	7	12
Black-capped chickadee	5	10
Crested flycatcher	5	10
Downy woodpecker	5	10
Wood thrush	4	8
Yellow-billed cuckoo	4	8
Red-bellied woodpecker	4	6
Acadian flycatcher	2	4
Tufted titmouse	2	4
Barred owl	1	2
Ruby-throated hummingbird	1	2
Hairy woodpecker	1	2
Phoebe	1	2
White-breasted nuthatch	1	2
Carolina wren	1	2
Eastern bluebird	1	2
Prothonotary warbler	2	2
Cerulean warbler	1	2
Scarlet tanager	1	2
Cowbird	present	present
Crow	2	2
Blue jay	present	present
Total	83	144

MAP 1.—Aerial photograph.



MAP 2.—Outline map of area.

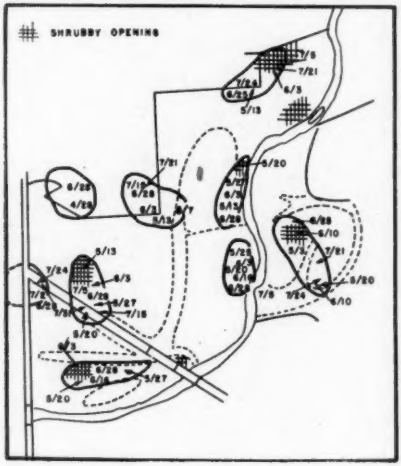
the large size attained by individuals. Sycamores, however, are the tallest and the largest trees in the forest, growing to a height of about a hundred feet. Hawthorn and hackberry form an important part of the high shrub stratum.

The lateral cutting of the river produces areas of deposition on the inside of curves of the streams and causes numerous changes of course of the stream with accompanying oxbows. These areas of recent deposition are characteristically covered by sapling maples (map 3) in nearly pure stands.

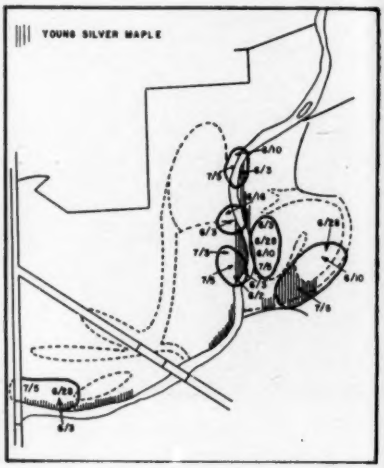
The methods of study were those used by Williams (1936). This consisted of marking the location of each bird seen on a previously mimeographed map of the area. Notes on bird behavior, climatic conditions, vegetation, river levels, and other pertinent information were recorded. Visits were made on the average of once a week. A composite map for each species was then made, as shown in the accompanying maps. Nesting territories can thus be estimated from them.

The species composition, as well as the total numbers of birds varied from season to season (table 6). The breeding population density is shown in table 2, the density being calculated on the basis of pairs per one hundred acres. When the territory of a given pair extended beyond the limits of the study area, it was assigned a value of a fraction of a pair, depending upon the relative amount of use of the territory that extended into the area. This method explains the apparent discrepancy of calculation in the table. For example, there were nine pairs of indigo buntings in the area, but only five had territories wholly in the area (map 3). Hence, the four portions of territories were assigned a value of one pair and the calculated density per hundred acres was twelve pairs.

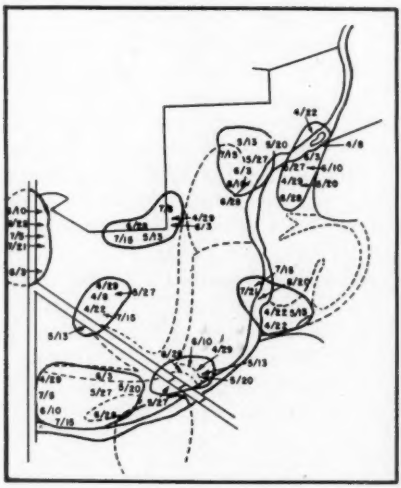
The density of 144 breeding pairs



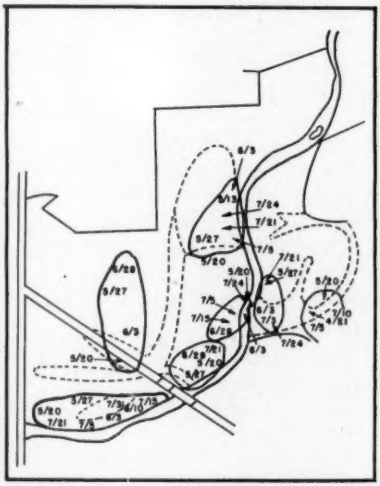
MAP 3.—Territories of Indigo buntings in relation to openings and edge.



MAP 4.—Territories of Redstarts in relation to stands of young silver maple.



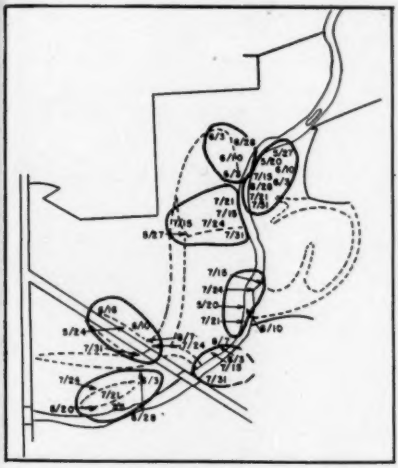
MAP 5.—Territories of Cardinals.



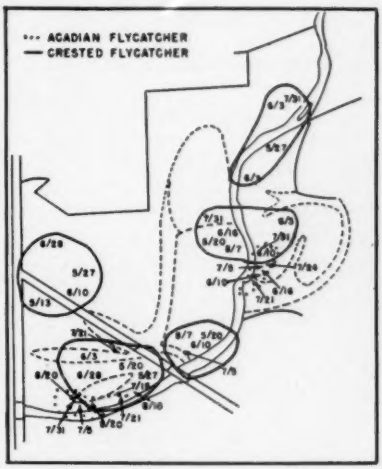
MAP 6.—Territories of Red-eyed Vireos.

per hundred acres compares favorably with that found by Williams (1937) and Deutschlander (1941) in an Ohio floodplain forest. They found 130 and 128 pairs per hundred acres, respectively.

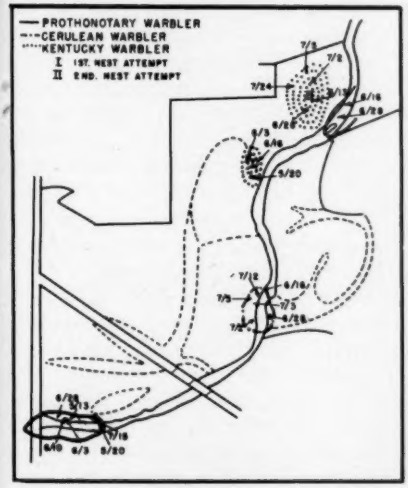
Although quantitative data are insufficient to present here, it was



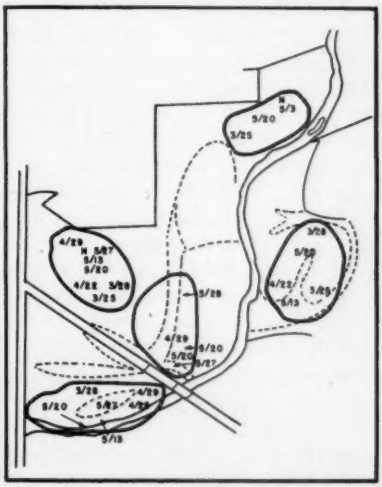
MAP 7.—Distribution of territories of Wood Pewees.



MAP 8.—Distribution of territories of Acadian and Crested Flycatchers.



MAP 9.—Territories of three species of Warblers.



MAP 10.—Territories of Downy Woodpeckers.

apparent that fluctuations in numbers occurred similar to those found by Williams (1936) and Twomey (1945). Permanent residents seemed to remain fairly constant in numbers during most of the year except immediately after the nesting season, when the young birds swelled the

TABLE 3.—WINTER POPULATION
(On the basis of four visits to area)

Species	Average number individuals in area	Individuals per 100 acres
Black-capped chickadee	17	34
Tufted titmouse	14	28
Cardinal	7	14
Downy woodpecker	4	8
White-breasted nuthatch	3	6
Carolina wren	3	6
Flicker	2	4
Hairy woodpecker	2	4
Red-bellied woodpecker	2	4
Barred owl	2	2
Purple finch	2	4
Blue jay	1	2
Brown creeper	1	2
Crow	Fluctuating	
Total	60	118

population for a period of sixty to seventy days during June and July.

One of the most important causes of increase in population was the influx of transients migrating further northward in spring. The population was also swelled by the arrival of the summer residents. It is noteworthy that these summer residents arrived in large numbers and only part of them remained to nest. This was characteristic of such species as indigo bunting, Kentucky warbler, and redstart, which arrived in a big wave the second week in May and only part of their number remained. Likewise, summer residents elsewhere in the region but not nesting on the floodplain increased this spring peak. Such species as the yellow-throat, catbird, and mourning dove were found in the area during the migration period only.

At the end of the nesting period there was a rapid decrease in the size of the bird population, rather than an increase that might have been expected. Such species as the prothonotary warbler and indigo bunting disappeared entirely from the area. It is interesting to note that in this same period there was an influx from elsewhere of immature robins, rose-breasted grosbeaks, and catbirds in large numbers. All these species fed voraciously upon the ripening wild grapes in the tree tops. Bronzed grackles, apparently the young of the year, were also seen feeding on the ground in the area. During this time wandering herons and wood ducks were found in the area. The addition of these birds tended to keep the summer population about stable in numbers despite the egress of the nesting residents.

With the coming of autumn, transients and the arrival of winter visitors again swelled the population to a second high peak. By the last of November, the transients and summer residents had left and only the winter visitors and permanent resi-

TABLE 4.—PERCENTAGES OF NESTING PAIRS OCCUPYING DIFFERENT LAYERS IN THREE COMMUNITIES

Type of forest	Beech–maple[1]	Elm–maple[2]	Floodplain[3]
Locality	Ohio	Illinois	Illinois
Layer			
Ground	10.1	2.3	1.3
Tree cavity	15.1	43.6	35.1
Tree canopy	29.4	17.3	16.4
Shrub	45.9	46.8	47.2

[1] Williams, 1936 (4 year average).
[2] Kendeigh, 1944 (11 year average).
[3] Present study.

TABLE 5.—SIZE OF NESTING TERRITORIES

Species	Number of territories measured	Average observed (Size in acres)	Maximum acreage available per pair
Cardinal	7	2.7	7.1
Red-eyed vireo	6	3.1	8.0
American redstart	6	1.4	7.7
Indigo bunting	6	2.2	7.5
Wood pewee	6	2.9	8.0
Black-capped chickadee	5	2.1	10.0
Crested flycatcher	5	3.1	10.0
Downy woodpecker	5	4.7	10.0
Yellow-billed cuckoo	3	2.5	12.5
Wood thrush	2	4.7	....
Red-bellied woodpecker	3	6.1	17.0
Tufted titmouse	2	4.0	....
Acadian flycatcher	2	1.7	....
Kentucky warbler	2	1.1	....
Prothonotary warbler	1	1.6	....
Cerulean warbler	1	1.3	....
Bluebird	1	3.5	....
Carolina wren	1	7.5	....
White-breasted nuthatch	1	5.7	....
Phoebe	1	0.7	....
Barred owl	1	40.0	....

dents remained. The winter visitors to the floodplain are small in numbers and species, as shown in table 3.

An outstanding and obvious influence of the river is affected through its repeated inundation of the floodplain. The first nesting attempt of one pair of Kentucky warblers was flooded out (map 9). It is noteworthy that the season of highest flood, both for the year of study and also for the previous year, occurred in June when most species of birds were nesting. Only 1.2 percent of the population are ground-nesting birds (table 4). This is low compared with upland communities and is probably a result of flooding. The oven-bird, one of the most abundant nesting species of the deciduous forest (Kendeigh, 1944), is conspicuously absent from the breeding pop-

ulation of the floodplain forest. Since this species nests on the ground, flooding doubtless prevents its nesting in this community; why nesting attempts are not made is open to speculation. The small layer of duff on the forest floor and the wet soil may be factors.

The indigo bunting was the only other low nesting species that could have been affected by floods. Dambach and Good (1940) found that indigo buntings were the only herb-shrub nesting species in a grazed woodland; grazing would have the same effect as flooding on ground-nesting species.

The flycatchers exhibited a decided preference for the forest edge along the river (maps 7 and 8). Gates (1911) also found this in a study of birds in a floodplain forest near Havana, Illinois. Since the river offers an open expanse of air for feeding, bordered by perches of various heights, such a situation is an ideal habitat for this group. Apparently it is the sharp transition from forest to open without gradual decrease in tree and shrub height that is important since the railroad offered a similar habitat niche and was utilized in a similar manner. The road also provided a suitable situation for at least one pair of wood pewees just outside the area of study. This theory is further substantiated by the fact that the flycatchers did not utilize the field and marsh edges which were characterized by a gradual transition in height from tree, shrub, to open area.

The importance of the river as a barrier was entirely negative. The width of the river is only about thirty feet, and, consequently, is not wide enough to be an obstacle to birds. Such species as the cardinal, cerulean warbler, and wood pewee defended territories that extended on both sides of the river. Birds were seen crossing the river at all seasons and often. The boundaries of some territories coincided with the river, but this was probably a response to the forest edge along the stream as a habitat niche rather than a barrier as the same species frequently used both sides of the river in one territory. Such species as the cardinal and wood pewee exhibited this behavior (maps 5 and 7).

The river and oxbows offered a supply of food to the kingfishers and herons. A kingfisher evidently nested in a river bank about 100 yards upstream from the area and fed regularly in the area along the river. Great blue herons, green herons, and black-crowned night herons fed in the tract all during the months of July and August. One immature black-crowned night heron spent several days in the vicinity of a drying slough, feeding on trapped minnows there.

During July and August the river was used as a watering and bathing site by the large influx of robins and rose-breasted grosbeaks, and it was doubtlessly important to other species as a source of water.

The forest edge along the river is the characteristic habitat of the prothonotary warbler. In central Illinois this species is confined to the larger stream valleys (Loucks, 1895).

The close relation of nesting indigo buntings to edge has been shown by Kendeigh (1944). A

TABLE 6.—BIRDS OF THE AREA—SEASONAL GROUPS

Permanent Residents

Barred owl, *Strix varia*
Red-bellied woodpecker, *Centurus carolinus*
Hairy woodpecker, *Dryobates villosus*
Downy woodpecker, *Dryobates pubescens*
Blue jay, *Cyanocitta cristata*
Crow, *Corvus brachyrhynchos*
Black-capped chickadee, *Parus atricapillus*
Tufted titmouse, *Parus bicolor*
White-breasted nuthatch, *Sitta carolinensis*
Carolina wren, *Thryothorus ludovicianus*
Cardinal, *Richmondena cardinalis*

Summer Residents

Red-shouldered hawk, *Buteo lineatus*
Yellow-billed cuckoo, *Coccyzus americanus*
Ruby-throated hummingbird, *Archilochus colubris*
Belted kingfisher, *Megaceryle alcyon*
Crested flycatcher, *Myiarchus crinitus*
Eastern phoebe, *Sayornis phoebe*
Acadian flycatcher, *Empidonax virescens*
Eastern wood pewee, *Myiochanes virens*
Wood thrush, *Hylocichla mustelina*
Red-eyed vireo, *Vireo olivaceus*
Prothonotary warbler, *Protonotaria citrea*
Cerulean warbler, *Dendroica cerulea*
Kentucky warbler, *Oporornis formosus*
American redstart, *Setophaga ruticilla*
Cowbird, *Molothrus ater*
Scarlet tanager, *Piranga olivacea*
Indigo bunting, *Passerina cyanea*

Autumn and Winter Visitors

Flicker, *Colaptes auratus*
Brown creeper, *Certhia familiaris*
Slate-colored junco, *Junco hyemalis*
Tree sparrow, *Spizella arborea*
Purple finch, *Carpodacus purpureus*

Transients (Autumn and Spring)

Whip-poor-will, *Caprimulgus vociferus*
Yellow-bellied sapsucker, *Sphyrapicus varius*
Olive-sided flycatcher, *Nuttallornis borealis*
Red-breasted nuthatch, *Sitta canadensis*
Winter wren, *Troglodytes troglodytes*
Hermit thrush, *Hylocichla guttata*
Olive-backed thrush, *Hylocichla ustulata*
Gray-cheeked thrush, *Hylocichla minima*
Golden-crowned kinglet, *Regulus satrapa*
Ruby-crowned kinglet, *Regulus calendula*
Warbling vireo, *Vireo gilvus*
Black and white warbler, *Mniotilta varia*
Golden-winged warbler, *Vermivora chrysoptera*
Magnolia warbler, *Dendroica magnolia*
Myrtle warbler, *Dendroica coronata*
Black-throated green warbler, *Dendroica virens*
Chestnut-sided warbler, *Dendroica pennsylvanica*
Palm warbler, *Dendroica palmarum*
Oven-bird, *Seiurus aurocapillus*
Canada warbler, *Wilsonia canadensis*
Rusty blackbird, *Euphagus carolinus*
White-throated sparrow, *Zonotrichia albicollis*
Fox sparrow, *Passerella iliaca*

Occasional Visitors

Great blue heron, *Ardea herodias*
Green heron, *Butorides virescens*
Black-crowned night heron, *Nycticorax nycticorax*
Wood duck, *Aix sponsa*
Turkey vulture, *Cathartes aura*
Cooper's hawk, *Accipiter cooperi*
Red-tailed hawk, *Buteo jamaicensis*
Bob-white, *Colinus virginianus*
Coot, *Fulica americana*
Mourning dove, *Zenaidura macroura*
Red-headed woodpecker, *Melanerpes erythrocephalus*
House wren, *Troglodytes aedon*
Catbird, *Dumetella carolinensis*
Brown thrasher, *Toxostoma rufum*
Robin, *Turdus migratorius*
Cedar waxwing, *Bombycilla cedrorum*
Starling, *Sturnus vulgaris*
Yellow-throated vireo, *Vireo flavifrons*
Water-thrush, *Seiurus noveboracensis*
Yellow-throat, *Geothlypis trichas*
Bronzed grackle, *Quiscalus versicolor*
Rose-breasted grosbeak, *Pheucticus ludovicianus*
Goldfinch, *Spinus tristis*
Towhee, *Pipilo erythrophthalmus*

similar relation was noted on the floodplain both along the river and also in openings of the forest canopy (map 3). This species prefers shrubby openings for nesting and high posts for singing.

The redstart seemed to exhibit strong tendencies to establish territories in young silver maple stands along the river (map 4). Probably any second growth deciduous trees would have been used either in stands or in edge such as described. Six of the nine pairs of cardinals in the study area used the forest edge made by the river (map 5).

There was a high percentage of shrub nesting species on the floodplain (table 4.). The number of pairs nesting in tree cavities was high and may be the result of large numbers of decaying and hollow trees. The percentage of species frequenting the tree canopy is correlated with the broken and relatively small extent of this layer. The edge effect of the river has been mentioned previously, and this effect is reflected in the fact that 20.2 percent of the breeding population was edge nesting species. Part of these species also nested in openings in the forest and on the edges produced by the field and marsh.

Another factor of importance to population density is that of competition. It seems probable that the strong competition for territory among cardinals was a limiting factor and indicated that this area was becoming saturated with this species. The minimum size to which the territory could be compressed would be of great importance here. The small size of cardinal territories is shown in table 5. Conflict for nesting territory was noted frequently between individuals of such species as cardinals and wood pewees.

An interesting question is raised concerning the competition between species. In several cases, territories of species closely related ecologically and taxonomically overlapped without visible conflict. Such is the case of the wood pewee, crested flycatcher, and Acadian flycatcher (maps 9 and 10). This lack of conflict might be partially explained by the fact that the crested flycatcher occupied the high tree top canopy, while the wood pewee and the Acadian flycatcher stayed in the lower branches of the trees. This segregation to different layers cannot be offered in explanation of the territorial overlaps between downy, hairy and red-bellied woodpeckers which also occurred in the floodplain forest.

Conflict between species did occur, however. This conflict was observed between the red-eyed vireo and the Kentucky warbler and between the wood pewee and the black-capped chickadee. A study of one breeding season, such as this one, only makes such a problem apparent. Further study of such factors would answer many problems in ecology.

The writer wishes to express his appreciation to S. Charles Kendeigh for aid and advice in preparation of this paper.

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A CONCENTRATION OF LEMMING MICE *(SYNAPTOMYS COOPERI)* IN CENTRAL ILLINOIS

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Lemming mice (*Synaptomys cooperi*) have long been regarded as rare in Illinois. Cory, in his report on the mammals of the state, says "So few specimens have been taken in Illinois that we know very little as to its habits in the state." (1912, 236). Even in 1941, Necker and Hatfield, in their account of the "Mammals of Illinois," list only 5 localities for the State from which specimens had been taken. Koestner (1941) and Goodnight and Koestner (1942) in studies of populations of mammals in central Illinois have emphasized the scarcity of individuals of the lemming mouse.

In the fall and winter of 1946-1947, our own investigations in central Illinois indicated that lemming mice were abundant at this time in their restricted habitat. They were caught at five previously unreported localities and were abundant at two of these places. Our most intensive investigation was undertaken along the Sangamon River, 5 miles west and 2½ miles south of Monticello, Piatt County, in the Allerton Park of the University of Illinois. Here there were several hundred, estimated at 650, acres of ungrazed, uncut blue-grass adjacent to the forest, with the latter extending down to the river's edge. Lemming mice were the dominant small mammal trapped in the Allerton Park during the fall and winter in this blue-grass habitat. Near the middle of November 1946, the number of *Synaptomys* was 35 per acre. This was more than twice the number of all the other mammals caught in the acre trapped. In February 1947, the population per acre was 20, and in March, 22 per acre (table 1) judging from our catch.

At first it was surmised that the large number of lemming mice at the fall period represented a peak in a cycle. Trapping was purposely extended through the winter in anticipation of a possible sharp decline in numbers of individuals. No such sharp decline occurred. The decline by some 40 percent from November to February was probably the result of "normal" predation without replacement by young. Females caught in February were without embryos, but on April 7 and 8 all the females caught were pregnant, as determined by the presence of a vaginal plug or embryos. Since reproduction did not extend through the winter, it might be inferred that this population of lemming mice had not reached the peak of its cycle of abundance, because information concerning other microtine rodents, such as *Microtus pennsylvanicus*, indicates that during the final year in a cycle, young are produced throughout the winter as well as the other seasons.

The three areas chosen in the Allerton Park for sampling the population and determining numbers of

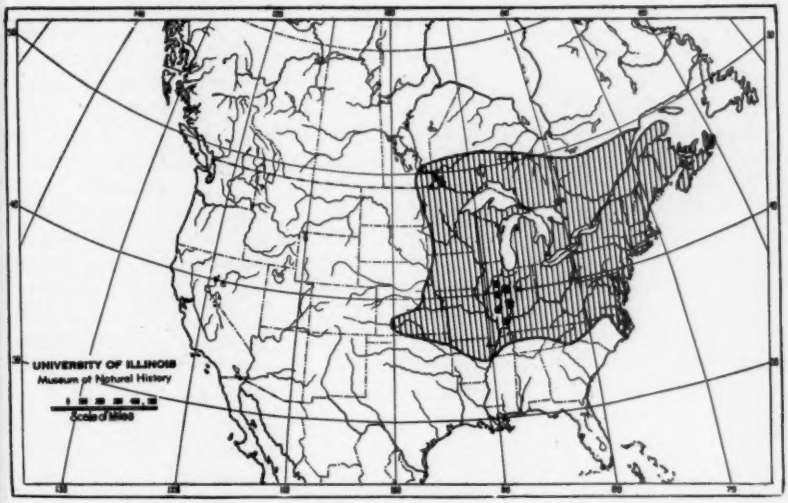

FIG. 1.—Map showing the distribution of the lemming mouse, *Synaptomys cooperi*, in North America, with localities from which specimens have been recorded in Illinois indicated by solid circles.

individuals were circular in shape. With such a shape, the perimeter is reduced and as a consequence there may be a reduction, at least theoretically, in the number of indrifting, "non-native" animals. Lemming mice are also probably more sedentary than some other kinds of small mammals and do less drifting, or shifting of home areas, when alterations in population densities occur. An acre was trapped for three days in November (10th to 12th) by D. G. Allison and R. M. Wetzel. The 130 snap-traps caught animals indicated in table 1. A half-acre, with 165 snap-traps, and five-eighths of an acre, with 97 snap-traps, were studied and trapped on February 23 and 24 and April 7 and 8, respectively. All three areas were in the grassland at the forest's edge. A few small trees were interspersed among the blue-grass. Here in the Allerton Park, lemming mice were closely associated with habitats that are predominantly, if not exclusively, of blue-grass, and are found in places where the blue-grass has not been cut or grazed for some time. The tall, uncropped blue-grass falls over providing cover and possibly protection to the surface runways, and the grass also provides a source of food. In areas in the Park where hay has been removed in the past few years, little or no sign of *Synaptomys* is evident. Wherever the lemming mice are numerous, their runways are littered with greenish fecal pellets, and in many places there is such a concentration of excreta as to form a solid mat on the floor of the runway. The presence of green fecal pellets however is not necessarily indicative of *Synaptomys* alone for the droppings

TABLE 1.—NUMBERS OF SMALL MAMMALS IN THE GRASSLAND ALONG THE SANGAMON RIVER, CENTRAL ILLINOIS, 1946-47

	Population per acre			Actual catch							Population per 650 acres		
	Nov.	Feb.	April	November (1 acre)			February (½ acre)		April (⅝ acre)		Nov.	Feb.	April
				10th	11th	12th	23rd	24th	7th	8th			
Lemming Mouse (*Synaptomys cooperi*)	35	20	22	8	13	14	7	3	9	5	22,750	13,000	14,300
Meadow Mouse (*Microtus ochrogaster*)	10	24	14	7	1	2	5	7	8	1	6,500	15,600	9,100
White-footed Mouse (*Peromyscus leucopus*)	6	6	0	2	2	2	2	1	0	0	3,900	3,900	.....
Least Shrew (*Cryptotis parva*)	0	4	0	0	0	0	1	1	0	0	.....	2,600	.....
Total	51	54	36								33,150	35,100	23,400

of the yellow-bellied meadow mouse, *Microtus ochrogaster*, occupying the same habitat, and probably the same runways, may be equally bright green. When these meadow mice are feeding solely on blue-grass, their fecal material is as green as that of *Synaptomys*.

Approximately 650 acres of grassland in the Allerton Park are suitable for occupancy by lemming mice. Superficial examination of many parts of this grassland indicates that these mice are just as abundant throughout the 650 acres as they were in the three plots that were trapped. If such an assumption is correct, one can estimate the total population of lemming mice in the Allerton Park to be 22,750 in November 1946 and 13,000 and 14,300 in February and April 1947 respectively. In spite of this concentration of lemming mice, they probably do little or no damage to the natural cover. The amount of blue-grass that they crop off has little effect upon the total cover as far as we could note. On the contrary the dry grass carried below ground adds important humus to the soil. After a heavy rain at the Allerton Park there was no free water on the surface of the ground for the excess water had been stored in underground runways. As a result of this the ground was so saturated with water that when one stepped on it the ground vibrated or quaked. The underground burrows hasten the penetration of surface water, retard run-off, and serve to retain excess water. These lemming mice are most likely beneficial, rather than detrimental, on the ungrazed, uncut grassland they occupy in at least some parts of Illinois.

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GROOMING DANCE AND ASSOCIATED ACTIVITIES OF THE HONEYBEE COLONY

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It is not within the province of this paper to describe the construction of a glass-sided observation hive for a colony of honeybees, but such a structure is highly recommended as a unit of instruction for every high school biology classroom. An established colony of bees may serve as a constant source of interest with a very low cost of installation, if the hive is constructed in a manual training or farm shop course.

Observations of honeybee activities may range all the way from entrance guarding activites to the innermost secrets of colonial life. These include the attention given the royal queen, her own activities in laying the eggs from which the entire ever-changing population of the colony develops, and the activities of the female workers in maintaining cluster temperatures, in carrying for the young, and in storing their food supplies.

Associated with the latter activities are certain well-known phenomena such as the pollen, nectar, and water dances. These dances are now considered to be a means of communication by which the incoming field bees pass on information to their fellow workers that sources of supply of pollen, nectar, and water are available.

In addition to these communication dances, other muscular exhibitions are designed principally for the creation of heat through the release of energy, either to warm the winter cluster to a highest temperature within the cluster of 75° to 85° F., or when brood rearing is in progress, to maintain an optimum temperature of near 93° F. in the brood rearing area. These heat producing activities consist of rapid breathing, vibration of the wings of individual workers for periods of several minutes, and at times a vigorous shaking of the body by individual bees within the cluster. There seems to be no doubt but that this last mentioned activity often has not been clearly differentiated from another hive activity on which we wish to report.

It has long been known by those who watch honeybees in observation hives that grooming or cleansing of the bodies of other bees is a service often rendered by one worker for a sister worker. Only recently, after sitting down to closely observe and possibly to describe this activity in detail, did we observe a more striking phenomenon, which to our knowledge has not been described previously. Much to our amazement, we soon noted that the grooming act is actually in response to a definite invitation by a worker apparently desirous of such attention.

Although a honeybee worker has many adapted structures on its legs for removing and transferring pollen and other materials to and from its various body parts, there seem to be certain areas which it cannot reach to perform its own cleansing operations. In particular, the quite

hairy region immediately caudad of or behind the points of wing attachment and extending back to the constriction between the thorax and abdomen is inaccessible to any leg structures of the individual bee, and thus the bee must depend on its sisters for grooming assistance.

Perhaps we can best describe the activities of the act if we assign some descriptive names to them. Because they are all females, possibly some beauty parlor terms would be more appropriate, but we can think of no better names than "customer" and "barber," respectively, for the "asking dancing bee" and her cooperating sister servant. As we have stated, the dance of the customer at first seems to be not unlike that of a bee that is apparently simply creating heat. In the latter case the individual worker bees may shake their bodies rapidly from side to side without attracting the attention of other workers except that sufficient room is usually allowed to avoid body contact. But the dance of a bee requiring or desiring the services of a barber seems to become more vigorous and is soon accompanied by attempts of her own to cleanse the antennae with the antennae cleaners of the front legs, of combing the hairs of the compound eyes with the pollen combs of the front legs, brushing the more posterior top and sides of the abdomen with the hind legs, but most vigorous of all, brushing the sides of the thorax with the second pair of legs.

It is at this point that the individual bee is somewhat in the predicament of the human with an itching back, particularly when the spot in question is between the points of the shoulder blades. In watching the frantic efforts of the customer bee it soon becomes apparent that she is not so constructed or provided with special leg structures for grooming portions of her own back, that is, the dorsal surface of the thorax and the anterior portion of the abdomen immediately behind the petiole, the narrowed constriction by which the abdomen is joined to the propodeum of the thorax.

The intervals of time required by the invitation dancers seem to vary considerably. In some cases a barber or grooming bee accepts the invitation or job almost immediately, in other cases there seems to be no response at all. We have been unable to determine whether a barbers' strike is in progress in such cases or whether it is just "Wednesday afternoon." In one case, we observed a worker jumping over an intervening bee, somewhat in the manner of a guard bee challenging the entrance of an incoming field bee, in this case apparently distracted by the dancing bee, but the grooming job was not accepted.

At certain times no invitation dances or grooming acts are observable, under which conditions we suspect that other activities and duties are of more immediate importance, as recently when fresh pollen was being brought in and there were numerous pollen dances in progress with the attendant excitement. On the other hand, on one occasion when there was no field activity or brood rearing, as many as a dozen grooming acts were in progress on one side of an individual frame of the observation hive.

If a near-by worker accepts the in-

vitation to grooming, she usually starts to work on the hairs near the constriction between the abdomen and thorax, spends comparatively little time on this region, and then moves forward to the region on the thorax behind the attachment of the wings where the hairs are the most concentrated, spending as long as six and one quarter minutes in one grooming act. The actual work seems to consist of combing the hairs by pulling them through the mandibles, although it is possible that portions of some hairs may be actually broken off in the process. Only the mandibles or chewing mouthparts are involved, the lapping mouthparts remaining folded beneath the head. At intervals during the grooming act, the barber backs up slightly and proceeds to clean her own mandibles, using her front legs in the process.

As soon as the grooming act is started, the customer bee ceases its dancing and thereafter gives complete cooperation by remaining motionless, even tilting the wings at a slight angle. In one instance two barbers were observed working on one customer. When one of the barbers backed up slightly to clean its mandibles, there was a slight confusion in positions and the second barber proceeded to groom the first barber. In this instance, there was no indication of any invitation having been extended. Many instances have been observed of two grooming acts in close contact with each other.

Further study may reveal more details and shed further light on the significance of these acts, but the observations to date indicate another way in which bees communicate with each other and manifest the cooperative spirit for which they have long been noted and praised for human exemplification.

MAJOR FLUCTUATIONS OF SOME ILLINOIS MAMMAL POPULATIONS

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The following notes constitute a partial history of fluctuations of some mammal populations in Illinois. They are often not continuous, nor made on equal bases, but in most cases constitute our only records. They are set down here in the belief that, when others are added in the future, the entire history will aid researchers in discovering specific causes of the fluctuations so as to predict and account for future changes.

Norway Rat

Beginning in the year 1934, the writer, while traveling widely in Illinois, recorded the numbers of certain animals seen crushed on the highway. During the course of the years up to 1939, he saw only one, two, or three rats crushed annually, usually only in cities.

In 1937 Starrett (1938) recorded only one rat per 1,255 miles in 7,529 miles of travel (3,229 during summer and early fall) within 80 miles of Peoria.

During 1939, however, the number seen crushed on highways increased suddenly. Two or three were seen during the course of most 200-mile trips. An average of one rat per 26 miles was seen during the course of the summer and fall over most of the state (fig. 1). The next year, 1940, was similar. An average of one rat per 34 miles was observed in 1,943 miles of travel. In 1941 the number seen fell to that of preceding normal years. Only two were seen in about 2,000 miles. The peak of greatest abundance had passed.

No observations were made during 1943, 1944, or 1945, but all farm advisers of 10 widely scattered county farm bureaus which were contacted state that rats were not unusually numerous during those years, though increasing somewhat in a few localities.

The writer's observations were continued early in 1946, records being made on the basis of mileage traveled. This was another year of large rat populations, the observed highway kills being more comparable with those of 1939 and 1940 than with any intermediate years. While

Technical and Common Names of Mammals Discussed

Gray fox	*Urocyon cinereoargenteus* (Schr.)
Groundhog	*Marmota monax* (Linn.)
Norway rat	*Rattus norvegicus* (Erx.)
Opossum	*Didelphis virginiana* Kerr.
Pennsylvania meadowmouse	*Microtus pennsylvanicus* (Ord.)
Prairie meadowmouse	*Microtus ochrogaster* (Wagn.)
Raccoon	*Procyon lotor* (Linn.)
Red fox	*Vulpes fulva* (Desm.)
Skunk	*Mephitis mephitis* (Schr.)

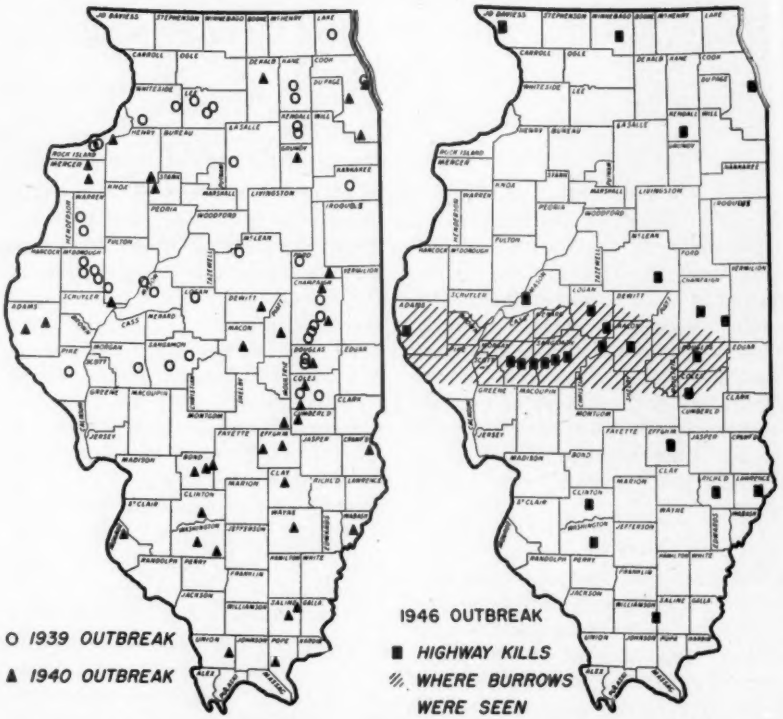

FIG. 1.—Localities where Norway rats or their signs were observed during two outbreaks, one of 1939 and 1940 and the other beginning in 1946. Circles, triangles and rectangles indicate localities where rats were seen dead on highways and streets. The hatched area indicates a zone where the writer observed large numbers of rat burrows alongside or in corn fields during the winter of 1946-47. Without doubt, a more intensive survey would have revealed burrows in a marginal area extending north, south and east of the area, though in much smaller numbers. No observations were made on distribution of burrows during the winters of 1939 and 1940.

traveling 5,726 miles from May 1946 to March 1, 1947, the writer observed 52 rats or one to approximately 110 miles. Because the number of rats observed crushed might depend much upon volume of traffic, comparative notes were made on cats whose number served as a basis. Ninety-eight were found killed, making about one rat to every two cats. During normal rat years, the number of cats observed crushed is a hundred or more in excess of rats.

Silver (1942) wrote "Their number varies locally from year to year though there is now no known cycle of rat abundance." There are few records of other outbreaks in Illinois.

Zinsser (1935) wrote "Dr. Lantz tells us that in 1903, hordes of rats migrated over several counties in

western Illinois, suddenly appearing when for several years no abnormal numbers had been seen." He adds that heavy damage was caused by rats in the entire surrounding country of farms and villages in the ensuing winter and summer.

Groundhog

The groundhog appears to be on the increase in many parts of Illinois, but the increase is not general. At Lima, Adams County, an orchardist stated that these animals had become very abundant about 1940 but that about 12 years ago, which would be about 1935, "he hardly knew what they were."

Much the same story was given by J. E. Watt, farm adviser at Fulton County, who stated that 25 years ago (1922) when he came to Fulton county, these animals were extremely scarce. Now they are a common problem.

The late W. P. Flint of the Natural History Survey stated that when he came to Illinois in 1918 groundhogs were practically unknown around Springfield and East St. Louis.

In Massac County they have become more numerous in the last 3 years and are now very numerous according to Leonard Devers, Department of Conservation Inspector.

The farm adviser in Carroll County states that groundhogs have become more numerous there during the last three years but that they are still relatively uncommon. Twelve to 15 years ago, he said, they were extremely numerous, then suddenly declined[1] in abundance.

The farm adviser of Whiteside County states that these animals are now relatively uncommon there. Neither are they especially numerous in Edgar County according to the county farm adviser.

Coon

An attempt to keep running index figures which might measure trends in furbearer populations was begun in 1934, using trapper's reports.[2] Although the total number of coons caught is so dependent on fluctuations in price, weather, and nature of persons reporting that it reveals but little, the percentage of trappers and furhunters who caught them, i.e. effective coon trappers, kept pace in considerable measure with known changes in coon populations. So did the average number of coons caught per effective trapper. The percentages and averages for each county were weighed according to county size and recorded by the writer (1943). They need not be repeated in detail here. For the 1934-35 season, the percentage-index was 24 and rose rather steadily to 37 during the 1941-42 season. Preliminary examination of 1945-46 data indicates that it continued to rise. A straight unweighted percentage shows the same general trend.

The average-index figure started at 2.6 and rose rather steadily to 3.0. This is, however, not necessarily regarded as accurate as the percentage-index figure.

Coon hunters and trappers, and game investigators are generally agreed that throughout Illinois coons are as common or more common this

[1] G. C. Oderkirk, federal predator and rodent control agent, says that an intensive campaign was conducted to reduce their number.

[2] These reports were kindly made available by the Honorable Livingston E. Osborne, Director of the Illinois State Department of Conservation, and preceding directors.

(1946-47) season as they have ever seen them. In Jo Daviess County, northwestern Illinois, Leroy Felderman, game investigator, stated that coon numbers increased markedly in the last three years and that an increase was noticeable there as long as 8 years ago. They are now seen in places where they were absent before.

A hunter in Alexander County, southwestern Illinois, stated that coons were scarce during 1917, of moderate numbers from 1930 to 1936, then became increasingly abundant, and are now more common than ever before within his memory. Their tracks are so numerous in cornfields that it looks as if a herd of hogs had been in them.

John C. Knight, Jr., reported in 1947 that his father had observed the territory around Yorkville, northeastern Illinois, for many years and stated that coon populations had never been as high as during this year. Coons there appeared to increase in numbers about four years ago.

Brown and Yeager (1943) state that many experienced furtakers were emphatic in their opinions that up to 1939 a decrease in coon populations had been steady and rapid during the preceding 5 to 10 years. During 1941 and 1942 when their report was being prepared for publication, they recorded that they had numerous and apparently reliable reports of increases in coon numbers, noticeable particularly in 1941 and 1942.

A hunter in Adams County, on the far western edge of Illinois, states that coons also became numerous there four years ago. Lyman Bunting, president of the coon-hunters association in Edwards County on the southeastern quarter of Illinois, stated that in 1942 or 1943 an abrupt natural increase became very apparent and that coons now exceed any previous number that he has known. Other similar statements are at hand from Rock Island, Will, and Mason counties. They generally set the beginning of noticeable increase for about 10 years ago and the beginning of a decided increase three or four years ago. This fits the trend indicated by the percentage-index and average-index described above. There is general agreement among the various opinions and indices that the rise began 10 to 12 years ago and has continued upward.

This increase cannot be attributed, for any practical purpose, to artificial coon propagation. It is widespread in eastern United States.

Possum

It is reasonable to suppose that if possum populations vary consistently some of the trend will be reflected in the percentage of trappers and fur-hunters taking them, as possums are caught in much the same time, place, and manner as coons are caught. Percentage-index figures recorded by the writer (1943) for the same years as for coons show, not a gradual rise from 1934 as for the latter animals, but a high of 74 which fell to a low of 60 for the 1937-38 season, then rose gradually to 68 during the 1939-40 season and dropped gradually to 61 during the 1941-42 season. The average-index figures showed the same general trend during those years. Considering the strong steady rise of the figures for coons

as a base for comparison, the possum figures undulated clearly with reference to them.

The general impression of the writer is that possums are now again numerous. During previous years of travel it was unusual to see a possum crushed on the highway more than once in some 1000 miles of travel. During the summer of 1946 and the following winter until March 1, 27 possums were observed for each 3.6 cats. Starrett (1938) recorded only two in 7529 miles of travel within 80 miles of Peoria during 1937.

A coon hunter in Edwards County and another in Mason County stated that possums are more numerous than usual there. They began to increase in numbers about 1942 or 1943. A game investigator in Mason County stated that possum populations were common for a while, then became uncommon, and are now on the upswing. He did not remember the years of abundance and scarcity. A trapper in Will County stated that their numbers were low three or four years ago but that they are common now.

The game investigator in Jo Daviess County, Leroy Felderman, stated that a marked increase in possum populations became apparent three years ago and that they are common now. In Massac County possums are now common, according to a coon hunter there, their numbers having increased since a low three or four years ago.

Brown and Yeager (1943) wrote that, in general, fur-takers who were interviewed reported a steady increase in possum numbers from 1936 to 1939 when populations seemed to level off or decrease. This is paralleled exactly by index figures cited above.

At this date we have no parallel index figures worked out from trappers data since 1942. The "lows" spoken of by the above observers appear to link up with the low of 61 for the 1941-42 data from trappers reports. All indicate a fairly regular undulation of population levels for the years in question.

Red Fox

According to a correspondent, John C. Knight, his father, keenly interested in fox hunting by tracking, found only few fox tracks after a long search in Kendall County seven or eight years ago. Now he finds such tracks without much search and has trouble following them because of the numerous other tracks.

According to a fox-runner, red fox numbers were lowest about 10 years ago in Massac County and are more common now than at any time within his memory. They are so common that, whereas he had to drive as much as 10 miles during the low population period to give his dogs a good trail, a half mile is now sufficient, and he can frequently start the dogs at his door. The numbers are so great that several dogs may start foxes, thus splitting the dog pack and making for a poor chase.

Leroy Felderman stated that the numbers of red fox were lowest in Jo Daviess County about 15 years ago and have now reached their all time high within his memory.

In Rock Island County, a coon hunter reported that they were lowest in number about 10 years ago

and have reached an all time high in his 35 years of experience.

In Adams and Mason counties, farmers stated that foxes have continued to increase in number for quite a few years and are now very common.

Percentage-index figures derived from trapper's reports for red and gray foxes combined show a general increase from 14 for the 1934-35 season to 16 for the 1941-42 season, last for which we calculated returns. There were, in this general upward trend, some fluctuations which may or may not indicate a corresponding minor change in actual fox populations. One of these was a drop back to 14 for the 1938-39 season and the other was a sudden rise to 18 for the 1940-41 season. The general trend, however, was upward and began 12 years ago.

According to Brown and Yeager (1943), of a total of 165 expressions of opinion tabulated by them up to 1939, by far the greater number (about 70 percent) believed that foxes had recently (1938 and 1939) increased in numbers. The remainder of opinion was equally divided between no change and decrease.

Index figures for both species of foxes by the writer (1943) agree with these opinions.

This increase is not by any means confined to Illinois but is widespread in eastern United States.

Gray Fox

Statements by trappers and fox-runners indicate that gray fox numbers generally fluctuate in about the same way red foxes do. Separation of the figures for grays is difficult but would be desirable. Any large changes in their numbers are commonly reflected in their appearance and disappearance in areas which are generally not too suitable for them. During the present (1946-47) season they are more frequently reported from well out in the prairie sections of Illinois.

Brown and Yeager (1943) were fortunately able to obtain separate data on gray foxes. These indicate strongly that this species was on the increase preceding and during the 1938-39 and 1939-40 trapping seasons. Seventy-five percent of 80 trappers interviewed believed that gray foxes had increased. Only 14 percent believed that they had decreased in numbers and 11 percent that the numbers had not changed essentially.

John C. Knight, Jr., reports that his father had up to 1940 gotten only two gray foxes in many years of hunting and trapping in Kendall County, but since then has gotten ten. The grays are now present in most of the wooded stream valleys around Yorkville, Kendall County, according to Knight.

Leroy Felderman stated that grays were now present in prairie sections in northwestern counties in Illinois where they were previously limited to the rougher more wooded sections. Their numbers had increased along with those of red foxes.

A fox runner in Massac County stated that both gray fox numbers and red fox numbers had increased beginning about ten years ago.

Skunk

Highway kills as described for rats and possums indicate relatively large numbers of skunks during the 1946-47 season. Seven were observed in 5,726 miles traveled from

May 1946 to March 1, 1947. This equals one skunk per 818 miles and one per 14 cats. The usual observed kill is one or two in several thousand miles and several hundred cats.

Lyman Bunting of Edwards County stated that 5 to 7 years ago skunks were dying of disease there but their numbers have since increased and they may be seen frequently.

Trapper's data converted for skunks as for coons, possums, etc. by the writer (1943) do not, as for some of the other furbearers, have sufficient parallel data for comparison. They indicate a general decline from 1934 to 1942. For the two years in particular question, they agree with trappers opinions described by Brown and Yeager (1943). They report a 33 percent decrease in the total number of skunks caught during the 1939-40 season as compared with the previous season and believe that this reflects a substantial decrease in actual populations. Their tabulation of opinions by fur takers regarding changes of population shows that essentially equal numbers believed that an increase or decrease had taken place, and that a small though substantial number thought that the population had remained about the same. These data indicate a general downward decline until about 1942, then a gradual rise.

Prairie Meadowmouse

Hamilton (1937) found "All available evidence points to a 4-year cycle" of Pennsylvania meadowmouse abundance in northeastern United States. He stated that past periods of great mouse abundance in New York were the winters of 1919-20, 1923-24, 1927-28, 1931-32 and 1935-36. He added that peaks of future cycles might accordingly be expected in the winters of 1939-40 and 1943-44.

The species of which he wrote only occurs in northern Illinois. It remains to be seen whether or not the cycles described by Hamilton are shared by the prairie meadowmouse whose distribution pattern is more extensive in Illinois.

This latter species did become extremely numerous over much of Illinois by the winter of 1939-40 but, according to R. E. Yeatter, a fellow worker, became abundant again in three years, not four. It then reached another peak of abundance at the end of three more years by the winter of 1945-46.

Prairie meadowmice were particularly abundant in northern and western Illinois during 1946 according to an annual report by Oderkirk (1947) unpublished.

They were more than usually abundant at Champaign during the late winter of 1945 and continued so until at least late fall of 1946. Farmers or farm advisers, again reported them particularly abundant in Fulton County during 1947; in Adams County during 1946 and 1947; in Monroe County during 1946 and 1947; and Sangamon County during 1946. They were also troublesome in one orchard in Lake County during 1946 and early 1947.

Farm advisers in Edwards, Henderson, Massac, Pulaski, and Alexander counties do not find them especially numerous. This is partly because in these counties, not being red-clover or alfalfa producing counties, farmers do not have trouble

with them and partly because the yellow soil areas do not, even during mouse years, have a large population. Meadowmouse numbers in Jo-Daviess County appear to be non-troublesome although the mice may be more numerous than usual where suitable conditions exist for them.

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PARASITES OF THE HYLIDAE (AMPHIBIA-HYLINAE). VI

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In this sixth section of the catalog of the parasites of the Hylinae, the following hosts and parasites are included:

1. HYLA FABER (Brazil)—*Cosmocerca brasiliensis, Foleyella convoluta, Oswaldocruzia subauricularis, Oxyascaris similis, Physaloptera* sp? of Travassos, 1928, *Raillietnema simples*, and *Spironoura nitida* (Nematoda); larval *Lueheia luehei* (Acanthocephala); *Cepedea plata, Nyctotherus faberi, N. fulvus, N. mogyanus, N. ruber, Opalina elongata, O. faber, O. longula*, and *O.* sp? of Carini, 1935 (Protozoa); and *Schmardaella lutzii* (Annelida).

2. H. FEMORALIS (U.S.A.)—*Ozysomatium americana* (Nematoda); and *Opalina obtrigonoidea*, and *O.* (?) *triangularis* (Protozoa).

3. H. FREYCINETI (Australia)—*Dolichosaccus diamesus*, and *Pleurogenes freycineti* (Trematoda); and *Nematotaenia* sp? of Johnston, 1916 (Cestoda).

4. H. FUSCOVARIA (S. Amer.)—*Cepedea ciliata, Isospora cruzi, Nyctotherus incertus*, and *N. ruber* (Protozoa).

5. H. GOUGHI (S. Amer.)—*Schmardaella* sp? of Lutz 1928 (Annelida).

6. H. GRACILENTA (Australia)—*Parathelandros mastigurus* (Nematoda); and *Mesocoelium microon* (Trematoda).

7. H. GRATIOSA (U.S.A.)—*Oxysomatium americana*, and *Spironoura catesbianae* (Nematoda).

8. H. INFRAFRENATA = *H. dolichopsis* (Papua)—*Protoopalina papuensis* (Protozoa).

9. H. JERVISIENSIS (Australia)—*Aplectana flindersi, Hedruris hylae*, and *Raillietnema kartanum* (Nematoda).

10. H. LANGSDORFII (Brazil)—*Aplectana* sp? of Travassos, 1925 (Nematoda); and *Nyctotherus faberi*, and *N. fulvus* (Protozoa).

11. H. LESUERII (Australia)—*Parapolystoma bulliense* (Trematoda); and *Entamoeba morula, E. ranarum, Trypanosoma* sp? of Johnston, 1916 and *T.* sp? of Laveran and Mesnil, 1912 (Protozoa).

12. H. LEUCOPHYLLATA (Brazil)—*Cepedea mogyana*, and *Nyctotherus ondinae* (Protozoa).

13. H. LUTEUS (Brazil)—*Aplectana acuminata and Cosmocerca commutata* (Nematoda).

14. H. MESOPHAEA (Brazil)—*Aplectana* sp? of Travassos, 1925, *Oswaldocruzia subauricularis*, and *Thelandros oswaldocruzi* (Nematoda); and larval *Centrorhynchus tumidulus* (Acanthocephala).

15. H. MICROPS (Brazil)—*Aplectana* sp? of Travassos, 1925 (Nematoda); and *Nyctotherus vulgaris* (Protozoa).

* Contributions from the Biological Laboratories of Knox College, No. 115.

16. H. MINUTA (Brazil)—*Cepedea rubra* (Protozoa).

17. H. MISERA (S. Amer.)—*Schmardaella lutzii* (Annelida).

18. H. NANA (S. Amer.)—*Zelleriella* sp? of Chen & Stabler, 1936 (Protozoa).

19. H. NASICA (Paraguay)—*Cepedea dimidiata paraguayensis*, and *Isospora cruzi* (Protozoa).

20. H. NASUTA (Australia)—*Trypanosoma* spp? of Bancroft, 1890, Johnston, 1916, and Laveran & Mesnil, 1912 (Protozoa).

21. H. NEBULOSA (S. Amer.)—*Cepedea rugosa, Myxidium lindoyense, Nyctotherus cinctus, N. elegans, N. ruber, Opalina nebulosa*, and *O.* sp? of Carini, 1935 (Protozoa).

22. H. PARDALIS (Brazil)—larval *Lucheia luehei* (Acanthocephala).

23. H. PERONII (Australia)—*Rhabdias hylae* (Nematoda); and *Entamoeba morula* (Protozoa).

24. H. PHRYNODERMA (Brazil)—*Aplectana* sp? of Travassos, et al., 1939 (Nematoda).

25. H. PHYLLOCHROA (Australia)—*Parapolystoma bulliense* (Trematoda).

26. H. POLITAENIA (S. Amer.)—*Nyctotherus ondinae, N. ruber*, and *N.* sp? of Carini, 1939 (Protozoa).

27. H. RADDIANA = *H. pulchella* (S. Amer.)—*Acanthocephalus lutzii* (Acanthocephala); and *Cepedea brumpti, Mastigamoeba hylae, Myxidium immersum, Nyctotherus* (?) *cordiformis, N. fragilis, Opalina raddiana, O.* sp? of Carini 1935, *Trypanosoma rotatorium, T. rotatorium major*, and *Zelleriella hylaxena* (Protozoa).

28. H. REGILLA (U.S.A.)—larval *Paralechriorchis syntomentera* (Trematoda) in tadpoles; larval *Centrorhynchus californicus* (Acanthocephala); and *Nyctotherus* (?) *cordiformis hylae* (= *N. hylae* of Rosenberg and (?) of Surowiak), *Opalina oregonensis, O. virguloidea*, and *Trichomonas augusta* (Protozoa).

29. H. RUBRA (S. Amer.)—larval *Strigea vaginata* (Trematoda); *Cepedea rubra, Isospora cruzi, Myxidium lindoyense, Nyctotherus mogyanus, N. tieteanus, Opalina elongata, O.* spp? of Carini, 1935-1937, *Trypanosoma borrelli, T. rotatorium*, and *T.* sp? of Laveran & Mesnil, 1912 (Protozoa); *Dermosporidium hylarum* (Phycomycetes); *Schmardaella lutzii* (Annelida); and *Eutrombicula yorkei*, and *Hannemania newsteadi* (Acarina).

30. H. SEPTENTRIONALIS (Cuba)—*Eustrongylides* sp? of Walton, 1940, *Oswaldocruzia lenteixeirai*, and *Pharyngodon bassi* (Nematoda); *Balantidium* sp? and *Nyctotherus* sp? of Metcalf, 1923, *Opalina septentrionalis*, and *Zelleriella* sp? of Metcalf, 1923 (Protozoa); *Schmardaella lutzii* (Annelida); and *Borrelia cubensis* (Bacteria).

31. H. SQUIRELLA (U.S.A.)—*Cosmocercoides dukae*, and *Rhabdias ranae* (Nematoda); larval and adult *Polystoma nearcticum* (Trematoda); *Cylindrotaenia americana* (Cestoda); and larval *Acariscus mansoni* (Acarina).

32. H. TASMANIENSIS (Australia)—*Nyctotherus* (?) *cordiformis* (Protozoa).

33. H. (?) TSCHUDII (Brazil)—*Aplectana acuminata*, and *Cosmocerca commutata* (Nematoda).

34. H. VENULOSA (S. Amer.)—*Balantidium* sp? of Metcalf, 1923, *Nyctotherus gamarrai, Trypanosoma* spp? of Laveran & Mesnil, and of Plimmer, 1912, and *Zelleriella venezuelae* (Protozoa); and *Schmardaella lutzii* (Annelida).

35. H. VERSICOLOR (U.S.A.)—larval *Apharyngostrigea pipientis*, *Cercaria amherstensis* (in tadpoles), *C. holthauseni* (in tadpoles), and larval *Polystoma nearcticum* (Trematoda); and *Balantidium* sp? of Metcalf, 1923, *Nyctotherus* (?) *cordiformis*, *Opalina hylaxena*, *O. h. georgiana*, *O. h. mexicana*, *O. h. orbiculata*, *O. h. parvinucleata*, *Scyphidia* sp? of Wenrich, 1924 (on tadpoles), *Trichomonas augusta*, *Trypanosoma* (?) *rotatorium*, and *T.* sp? of Negrelli, 1945 (Protozoa).

36. H. VERSICOLOR CHRYSOSCELIS (N. Amer.)—*Cepedea* sp? and *Opalina* sp? of Metcalf, 1923 (Protozoa).

37. H. sp? (Australia)—*Dolichosaccus* spp? of Johnston, 1912, and *Pleurogenes* sp? of Roberts, 1936 (Trematoda).

38. H. sp? (Brazil)—*Ascaris foecunda* (Nematoda); and larval *Clinostomum heluans*, and larval *Echinostoma nephrocystis* (Trematoda).

39. H. sp? (Europe)—*Oswaldocruzia* sp? of Dikmans, 1932 (Nematoda).

40. H. sp? (Japan)—*Capillaria filiformis* (Nematoda).

41. H. sp? (N. Amer.)—*Triatoma sanguisuga ambigua* (Hemiptera).

A survey of the records of this and the earlier studies indicates that the "Tree Frogs" of the family *Hylidae* are widely distributed and heavily parasitized. 71 identified and 5 unidentified host species have been examined as follows: ACRIS (3 spp.) from the U.S.A., AGALYCHNIS (2 spp.) from Central America, HYLA (63 spp.) from all of the continents except Africa (1 sp. from Asia Minor, 14 spp. from Australia, 4 spp. from Central America, 1 sp. from Cuba, 3 spp. from Europe, 2 spp. from Japan, 2 spp. from Mexico, 1 sp. from Papua, 23 spp. from S. America (20 from Brazil), and 12 spp. from the U.S.A. and Canada), PHYLLOMEDUSA (2 spp.) from Central and Northern S. America, and PSEUDACRIS (6 spp.) from the U.S.A. The *Hylidae* apparently originally evolved in the South American rain-forest area (about 100 spp. are reported) and spread to North America (about 50 spp. are known). The presence of over 40 spp. of hylids in Australia necessitates consideration of the possibility of an independent center of origin from archaic bufonids of the region. This seems doubtful inasmuch as the parasites of the hylids do not seem to have arisen from those of the bufonids as is the case in South America, but show direct relationship to some of the more highly modified types of the less primitive New World host species. Migration from a Western Hemisphere source seems therefore much more plausible than independent origin although it requires the postulation of southern land bridges between Australia and South America, either by direct trans-Pacific crossing or via the Antarctic Continent. Hylids appeared in Australia too late to have entered by way of the Malayan land bridge. Arldt and other paleogeographers have advanced evidences of former land bridges in Late Cretaceous or Early Tertiary times, extending: (a) from Peru westward through the chain of islands of the modern South Pacific to Australia and New Guinea; and (b) from Chile southeastward through present-day islands to Antarctica and thence westward and northward to Australia

and New Guinea. Such data are not conclusive in the opinion of many other paleogeographers. The Australian hylids are more nearly related to South American species than they are to the North American or European forms and thus a northern pathway from South America to Australia seems to be ruled out even though such a migration should have occurred early enough to have used the Malayan bridge which, however, is usually regarded as having disappeared before the appearance of the hylids. It is difficult to believe that all connecting forms should have entirely been wiped out and replaced by the more modern species which are traceable directly back to a Neotropical ancestry. The present 5 or 6 Eurasiatic hylids (mainly varieties of *Hyla arborea*) are definitely late Tertiary derivatives of North American species and entered their area by way of the Alaska-Siberia preglacial land bridge. These North American forms antedate the Australian forms but could not have been ancestral to them.

Study of the parasites bears out the same general conclusion of the Late Cretaceous and Early Tertiary evolution of the Hylidae inasmuch as few of the nematode, the trematode, or the protozoan species found are truly primitive forms. Metcalf has presented this analysis in detail for the opalinid protozoans, and a survey of the other protozoa and of the metazoa involved substantiate his interpretations.

The two species of *Acris* from North America show the presence of 6 species of nematodes, 3 species of cestodes, and 9 species of protozoans. The two species of *Agalychnis* from Central America show 2 species of Opalinids. The two species of *Phyllomedusa* from Central America and Northern South America are hosts to 1 species of nematode and to 2 species of protozoans. The six species of *Pseudacris* from North America are parasitized by 9 species of nematodes, 5 species of trematodes (several of them only in larval form), 1 species of cestode, 1 species of a larval acanthocephalan, and 12 species of protozoans. The four identified and two unindentified species of *Hyla* from Eurasia (including Japan) are reported as hosts of 8 adult and 1 larval species of nematodes, 10 adult and 5 larval species of trematodes, 2 adult and 2 larval species of cestodes, 1 adult and 1 larval species of acanthocephalans, 18 identified and 4 unidentified species of protozoans, 1 species of bacterium, and 1 species of a fly maggot. The adults of the larval species are normally found in birds or reptiles, the amphibia serving only as intermediate, or in some cases, as accidental hosts. 14 species of *Hyla* from Australia are parasitized by 8 adult and 2 larval species of nematodes, 18 species (2 not identified) of trematodes, 5 species of adult (3 identified only as to genus) and 1 species of larval cestodes, 1 species of larval acanthocephalans, 18 species of protozoans, and 1 species of a larval dipteran. The one *Hyla* species from Papua was parasitized by a single form of the protozoans. The 4 species of *Hyla* from Central America and the northern border of adjacent South America are hosts to 1 species of trematode, to 9 species of protozoans, and to 1 species of annelid.

Specimens of 2 species of hylids from Mexico and adjacent Central America yielded 1 species of nematode, 1 species of trematode, and 5 species of protozoans. The one hylid species examined from Cuba was host to 2 adult and 1 larval species of the nematodes, 4 species of protozoans, 1 of an annelid, and 1 of a bacterium. 12 species of nematodes (including 3 larval species), 12 species of trematodes (including 4 species of larval forms whose adults are found in birds or reptiles and 2 species of metacercariae whose adults are as yet unknown), 1 adult and 2 larval species of cestodes, 2 species of larval acanthocephalans, 25 species of protozoans, 2 species of larval mites, and 1 species of an hemipteran, have been reported from the genus *Hyla* taken in the United States and in Canada. The 27 South American species of *Hyla* (20 species from Brazil) are hosts to 12 adult and 2 larval species of nematodes, 4 species of larval trematodes, 1 adult and 2 larval species of acanthocephalans, 40 identified species of protozoans, 1 species of an annelid, 1 species of a phycomycete, and 2 species of larval mites.

Among the Nematoda, 22 genera and 40 identified species are present. Eight larval forms, identified only as to their genera, are also reported. *Aplectana* with 4 species, *Cosmocerca* with 3, *Oswaldocruzia* with 7, *Rhabdias* with 3, and *Spironoura* with 4, are the genera most frequently encountered. *Rhabdias* is the most widely distributed genus, species being reported from 11 different hosts, collected from all of the continents where hylids are found. *Cosmocercoides dukae* is the one species occurring in the greatest number of hosts, six, although thus far reported only from the North American area. 14 species of nematodes are reported from the U.S.A., 13 from South America, 10 from Australia, 6 from Europe, 3 each from Japan and from Cuba, and 1 from Mexico. *Aplectana acuminata* and *Cosmocerca commutata* are the only species definitely identified as being present on two continents, Europe and South America.

NEMATODE PARASITES[1]

**Agamascaris enopla* U.S.A. (1)
**Agamascaris odontocephala* U.S.A. (3)
**Agamonema* sp? Australia (1)
Aplectana acuminata E., S. Amer. (1 each)
Aplectana flindersi Australia (1)
Aplectana hamatospicula Mexico (1)
Aplectana spp? S. Amer. (5)
Ascaris foecunda S. Amer. (1)
Capillaria filiformis Japan (1)
Cosmocerca brasiliensis S. Amer. (1)
Cosmocerca commutata E., S. Amer. (1 each)
Cosmocerca japonica Japan (1)
Cosmocercella haberi U.S.A. (1)
Cosmocercoides dukae U.S.A. (6)
**Eustrongylides* sp? Cuba (1)
Foleyella convoluta S. Amer. (1)
Hedruris hylae Australia (1)
Oswaldocruzia filiformis E. (1)
Oswaldocruzia leidyi U.S.A. (3)
Oswaldocruzia lenteixeirai Cuba (1)
Oswaldocruzia limnodynastes Australia (1)
Oswaldocruzia minuta U.S.A. (1)
Oswaldocruzia pipiens U.S.A. (3)
Oswaldocruzia subauricularis S. Amer. (3)
Oswaldocruzia sp? E. (1)
Oswaldocruzia sp? S. Amer. (1)
Oxyascaris similis S. Amer. (1)
Oxysomatium americana U.S.A. (3)
Oxysomatium brevicaudatum E. (1)
Oxyuris tba E. (1)
Parathelandros mastigurus Australia (2)
Pharyngodon bassi Cuba (1)
**Pharyngodon confusa* Australia (1)
**Pharyngodon* sp? S. Amer. (1)
**Pharyngodon* spp? U.S.A. (3)
Raillietnema kartanum Australia (1)

[1] *Denotes larval forms. Number in parentheses indicates the number of host species from which the parasite has been reported. E. refers to Europe.

Raillietnema simples S. Amer. (1)
Rhabdias bufonis Japan (1)
Rhabdias hylae Australia (3)
Rhabdias ranae U.S.A. (4)
Rhabdias sp? Australia (1)
Rhabdias sp? U.S.A. (2)
Spironoura catesbianae U.S.A. (2)
Spironoura hylae U.S.A. (1)
Spironoura nitida S. Amer. (1)
Spironoura simpsoni Australia (1)
Thelandros oswaldocruzi S. Amer. (1)
Thubunaia liolopisma U.S.A. (1)
(normally in lizards)

Thirty-one genera (43 identified and 6 unidentified species) of trematodes have been reported from members of the *Hylidae*. *Mesocoelium* with 4 species, *Pleurogenes* with 5, and *Polystoma* with 4 are the best represented genera. *Brachycoelium salamandrae, Megalodiscus temperatus, Opisthodiscus subclavatus,* and *Polystoma nearcticum* have each been reported from 3 host species. *O. subclavatus* is the only species to be reported from two continents (Australia and Europe). The 2 species of "Cercaria" have been reported from tadpoles, but their life-histories are asyet undetermined and their adult forms not as yet ascertained. 12 additional larval species are recorded—their adult forms being found in fish, reptiles, and birds —with the amphibians merely serving as intermediate hosts. 18 species of parasites are reported from Australia, 15 from Europe, 12 from the U.S.A., 4 from South America, and 1 from Central America and Mexico.

TREMATODE PARASITES

Asymphlyodora tincae E. (1)
**Apatemon gracilis* S. Amer. (1)
**Apharyngostrigea pipientis* U.S.A. (1)
Brachycoelium salamandrae U.S.A. (3)
Brachysaccus anartius Australia (1)
Brachysaccus symmetricus Australia (1)
**Cercaria amherstensis* (tadpoles) U.S.A. (1)
**Cercaria holthauseni* (tadpoles) U.S.A. (1)
**Clinostomum heluans* S. Amer. (1)
**Dasymetra villicaeca* U.S.A. (2)
Distomum sp? U.S.A. (1)
Distomum sp? Australia (1)
**Dolichoenterum lemirandi* E. (1)
Dolichosaccus diamesus Australia (1)
Dolichosaccus ischyrus Australia (1)
Dolichosaccus tryphesus Australia (1)
Dolichosaccus spp? Australia (2)
**Echinoparyphium recurvatum* E. (1)
**Echinostoma nephrocystis* S. Amer. (1)
Glypthelmins quieta U.S.A. (2)
Glypthelmins sp? U.S.A. (1)
Gorgodera australiensis Australia (1)
Gorgodera cygnoides E. (1)
Haematoloechus australis Australia (1)
Haplometra cylindracea E. (1)
Lecithochirium rufoviride E. (1)
Lecithopyge ranae E. (1)
Megalodiscus temperatus U.S.A. (3)
Mesocoelium megaloon Australia (1)
Mesocoelium mesembrinum Australia (2)
Mesocoelium microon Australia (2)
Mesocoelium oligoon Australia (1)
**Neorenifer aniarum* U.S.A. (2).
Opisthodiscus subclavatus E., Australia (3)
**Paralechriorchis syntomentera* U.S.A. (1)
Parapolystoma bulliense Australia (2)
Pleurogenes claviger E. (1)
Pleurogenes freycineti Australia (1)
Pleurogenes medians E. (1)
Pleurogenes solus Australia (1)
Pleurogenes sp? Australia (1)
Polystoma gallieni E. (1)
Polystoma integerrimum E. (2)
Polystoma naevius Mex., Cent. Amer. (1)
Polystoma nearcticum U.S.A. (3)
**Prosorhynchus aculeatus* E. (1, exper.)
**Sphaerostoma bramae* E. (1)
**Strigea vaginata* S. Amer. (2)
**Szidatia joyeuxi* E. (1)

Among the Cestodes, 9 genera—with 7 identified and 5 unindentified species (5 of the 12 are larval forms) —are parasitic in the *Hylidae*. At least 1 species of a proteocephalid is present in encysted form, 2 species of *Sparganum* larvae and 1 species of a larval *"Taenia"* are reported. *Ophiotaenia* is represented by 2 species, one each from Australia and from the United States. *Nematotaenia dispar* has been recovered

from 2 host species, 1 each from Europe and from the United States. Probably this same species has been recovered from 2 host species in Australia, but the identification was not completely established. *Cylindrotaenia americana* has been reported from 3 different U.S.A. hosts. Australia reports 5 species, the U. S. A. 5 species, Europe 3 species and Japan 1 species of tapeworms. South America has no recorded findings of cestodes as parasites of the hylids.

CESTODE PARASITES

Baerietta japonica Japan (1)
Cylindrotaenia americana U.S.A. (3)
**Diphyllobothrium erinacei* E. (1)
Nematotaenia dispar E., U.S.A. (1 each)
N. spp? Australia (2)
Ophiotaenia hylae Australia (1)
Ophiotaenia magna U.S.A. (1)
Ophiotaenia sp? Australia (1)
*Proteocephalid cysts U.S.A. (1)
**Sparganum* spp? Australia (2)
**Taenia* sp? U.S.A. (1)
**Tetrathyridium* sp? E. (1)
Triplotaenia mirabilis Australia (1)

Acanthocephala (2 adult and 7 larval species) are represented by 3 genera. Hosts from Australia, Europe, North America, and South America, have been found to be parasitized.

ACANTHOCEPHALAN PARASITES

**Acanthocephala hylae* Australia (2)
Acanthocephala lutzii S. Amer. (1)
Acanthocephala ranae E. (1)
**Centrorhynchus aluconis* E. (1)
**Centrorhynchus californicus* U.S.A. (1)
**Centrorhynchus tumidulus* S. Amer. (1)
**Centrorhynchus* spp? U.S.A. (2)
**Lueheia luehei* S. Amer. (2)

The Protozoa of the *Hylidae* have been carefully studied by Carini and by Metcalf, and are perhaps better known than are any of the other groups of parasites. 21 genera (plus 2 unidentified protozoans) and 81 species (plus 49 unidentified and possibly identical species) have been reported. Australia is represented by 10 genera and 15 species of protozoans, and New Guinea by 1 species. Asia is represented by 1 species, present both in Japan and in Asia Minor. Europe is represented by 9 genera and 22 species. In North America, the U. S. A. records show the presence of 10 genera and 39 species, Mexico the presence of 2 genera and 2 species, Central America and adjacent South America 3 genera and 4 species, and Cuba 4 genera and 4 species. South American records show the presence of 9 genera and 46 species. The genus *Opalina* is represented by 39 species, some of which are probably duplicates. As the author has pointed out earlier (1941), *Opalina obtrigonoidea* and *O. triangularis* are probably identical, with *O. triangularis* having priority. The validity of the varietal forms of *O. hylaxena*, of *O. obtrigonoidea* (? *O. triangularis*), and of *O. virguloidea* was also questioned in the same article. *Opalina* is primarily a genus of the Western Hemisphere, although one species has invaded Eurasia. The reported presence of the genus in Australia is seriously to be doubted. The genus *Nyctotherus* is represented by 24 species, again some of which are undoubtedly cases of overlapping identifications. The genus is of New World origin, but has penetrated into Europe as *N. cordiformis* and into Australia. The identification of *N. cordiformis* in other than European hosts is to be questioned (1941). *Trypanosoma* is represented by 18 species (some unquestionably are overlapping

identifications) from Australia, Europe, North America, and South America. With the possible exception of *T. grylli*, students of the group seriously question whether any of the species reported from the *Hylidae* are other than host variants of *T. rotatorium*. *Cepedea*, represented by 11 species found in tropical and sub-tropical American hosts, is preëminently a South American genus. 5 species of *Protoopalina* are reported. Members of this genus are late invaders of the hylids, being found only in Europe and Australia —areas in which the hylids are relatively new invaders. The reported presence of *P. intestinalis* (a European form) in an Australian hylid is to be questioned. *Zelleriella*—with 5 species reported—is another tropical form, and thus far has been found only in the New World as far as hylid hosts are concerned. At least 8 different hosts have been reported as carrying *Balantidium* species, but as specific identifications are lacking, further comment is impossible at present. The genus *Isospora* is the only other protozoan genus with as many as 3 species that parasitize hylids. *Trichomonas augusta* in 6 host species, *Nyctotherus ? cordiformis* (U.S.A.) in 8 hosts, *Opalina chlorophili* in 6 hosts, *O. triangularis* (*? obtrigonoidea*) in 10 hosts, *O. virguloidea* in 5 hosts, and *Trypanosoma ?rotatorium* in 14 hosts, are the least host-specific species.

PROTOZOAN PARASITES

"Amoeba" sp? Australia (1)
Balantidium sp? Australia (1)
Balantidium sp? Cent. & S. Amer. (1)
Balantidium sp? Cuba (1)
Balantidium sp? Mexico & Cent. Amer. (1)
Balantidium sp? S. Amer. (1)
Balantidium sp? U.S.A. (2)
Cepedea baudinii Mex. & Cent. Amer. (1)
Cepedea brumpti S. Amer (1)
Cepedea ciliata S. Amer. (1)
Cepedea dimidiata paraguayensis S. Amer. (1)
Cepedea globosa Cent. Amer. (1)
Cepedea mogyana S. Amer. (1)
Cepedea multiformis Cent. & S. Amer. (1)
Cepedea plata S. Amer. (1)
Cepeda rubra S. Amer. (2)
Cepedea rugosa S. Amer. (1)
Cepeda sp? U.S.A. (1)
Cytamoeba grassi E. (1)
Eimeria belawini E. (1)
Entamoeba morula Australia (3)
Entamoeba ranarum Australia (1)
Eutrichomastix sp? Australia (1)
Giardia agilis E. (1)
Haemogregarina hylae Australia (1)
Hexamita intestinalis U.S.A. (2)
Hexamita sp? U.S.A. (1)
Isospora cruzi S. Amer. (4)
Isospora hylae E. (1)
Isospora wladimirovi E. (1)
Mastigamoeba hylae S. Amer. (1)
Mixidium immersum S. Amer. (1)
Mixidium lindoyense S. Amer. (2)
Myxobolus hylae Australia (1)
"Myxosporidium" sp? Australia (1)
Nyctotherus cinctus S. Amer. (1)
Nyctotherus cordiformis Australia (2)
Nyctotherus cordiformis E. (1)
Nyctotherus cordiformis S. Amer. (2)
Nyctotherus cordiformis U.S.A. (6)
Nyctotherus cordiformis hylae E. (1)
Nyctotherus cordiformis hylae U.S.A. (1)
Nyctotherus cunhai S. Amer. (1)
Nyctotherus elegans S. Amer. (1)
Nyctotherus faberi S. Amer. (1)
Nyctotherus fragilis S. Amer. (1)
Nyctotherus fulvus S. Amer. (1)
Nyctotherus gamarrai S. Amer. (1)
Nyctotherus hylae E. (1)
Nyctotherus incertus S. Amer. (1)
Nyctotherus mogyanus S. Amer. (2)
Nyctotherus ondinae S. Amer. (2)
Nyctotherus ruber S. Amer. (3)
Nyctotherus tieteanus S. Amer. (1)
Nyctotherus vulgaris S. Amer. (1)
Nyctotherus spp? Australia (2)
Nyctotherus sp? Cuba (1)
Nyctotherus sp? E. (1)
Nyctotherus spp? N. Amer. (3)
Nyctotherus sp? S. Amer. (1)
Opalina chlorophili U.S.A. (6)
Opalina elongata Cent. & S. Amer. (1)
Opalina elongata S. Amer. (2)
Opalina faber S. Amer. (1)
Opalina guatamalae Mex. & Cent. Amer. (1)

Opalina helenae Cent. & S. Amer. (2)
Opalina hylaxena U.S.A. (3)
Opalina hylaxena georgiana U.S.A. (1)
Opalina hylaxena mexicana U.S.A. (1)
Opalina hylaxena orbiculata U.S.A. (1)
Opalina hylaxena parvinucleata U.S.A. (1)
Opalina longula S. Amer. (1)
Opalina moreletei Cent. Amer. (1)
Opalina nebulosa S. Amer. (1)
Opalina oblanceolata U.S.A. (1)
Opalina obtrigona Asia Minor (1)
Opalina obtrigona E. (1)
Opalina obtrigona Japan (1)
Opalina obtrigonoidea U.S.A. (4)
Opalina obtrigonoidea orbiculata U.S.A. (1)
Opalina oregonensis U.S.A. (1)
Opalina pickeringii U.S.A. (2)
Opalina raddiana S. Amer. (1)
Opalina septentrionalis Cuba (1)
Opalina terrae-mariae U.S.A. (1)
Opalina triangularis U.S.A. (5)
Opalina virguloidea Mexico (1)
Opalina virguloidea U.S.A. (3)
Opalina virguloidea macronucleata U.S.A. (1)
Opalina virguloidea micronucleata U.S.A. (1)
Opalina sp? Australia (1)
Opalina spp? E. (3)
Opalina spp? S. Amer. (5)
Opalina spp? U.S.A. (4)
Protoopalina adelaidensis Australia (1)
Protoopalina australis E. (1)
Protoopalina hyalarum E. (1)
Protoopalina intestinalis Australia (1)
Protoopalina intestinalis E. (1)
Protoopalina papuensis New Guinea (1)
Retortamonas dobelli U.S.A. (1)
Scyphidia sp? U.S.A. (1)
Trichomonas augusta Mexico (1)
Trichomonas augusta U.S.A. (6)
Trichomonas batrachorum E. (1)
Trypanosoma borrelli S. Amer. (1)
Trypanosoma grylli U.S.A. (1)
Trypanosoma hylae E. (1)
Trypanosoma rotatorium E. (1)
Trypanosoma rotatorium S. Amer. (2)
Trypanosoma rotatorium U.S.A. (4)
Trypanosoma rotatorium major S. Amer. (1)
Trypanosoma spp? Australia (4)
Trypanosoma spp? E. (3)
Trypanosoma spp? S. Amer. (3)
Trypanosoma spp? U. S. A. (3)
Zelleriella hylaxena S. Amer. (1)
Zelleriella venezuelae S. Amer. (1)
Zelleriella sp? Cuba (1)
Zelleriella sp? S. Amer. (1)
Zelleriella sp? U.S.A. (1)

One member of the annelid group has been reported from 9 different species of the Neotropical *Hylidae*.

Schmardaella lutzii. 4 host species from Central and adjacent South America. 1 host species from Cuba. 2 host species from South America.
Schmardaella sp? (probably *S. lutzii*). 2 different host species from South America.

Three genera and 4 species of larval ticks have been recorded as feeding on 3 different host species of New World hylids.

**Acariscus mansoni* U.S.A. (1)
**Eutrombicula yorkei* S. Amer. (1)
**Hannemania hylae* U.S.A. (1)
**Hannemania newsteadi* S. Amer. (1)

Larval dipterans are reported from Australia and Europe (2 genera and 2 species) as parasitic in members of the *Hylidae*.

**Batrachomyia* sp? Australia (1)
**Lucilia bufonivora* E. (1)

One hemipteran is reported as feeding on a North American hylid

Triatoma sanguisuga ambigua U.S.A. (1)

Two genera and 2 species of bacteria have been isolated from host lesions, one from Cuba and one from Europe. *Borrelia cubensis* n. comb., is suggested for *Spirochaeta cubensis* Hoffman, 1923, inasmuch as the genus *Spirochaeta* s.s. is now reserved for the nonparasitic members of that group of organisms.

Borrelia cubensis Cuba (1)
Micrococcus batrachorum E. (1)

One mold has been isolated from skin lesions on a South American species of *Hyla* (*H. rubra*).

Dermosporidium hylarum S. Amer. (1)

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AN INVESTIGATION OF SOME POSSIBLE SOURCES OF TRICHINA INFECTION IN A CENTRAL ILLINOIS COMMUNITY

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According to Chandler, 1944, the incidence of infection by *Trichinella spiralis* is lower in the "Grain Belt" than in other regions of the United States. He suggests that the incidence of infection in both man and hog is correlated with methods of feeding hogs in different parts of the country. We have been unable to find recent publications relevant to possible sources of infection in this area. Because we were unable to find published data for this area, this study was conducted.

We have found data published in the last ten years giving the following percentages in the regions named: Kerr, 1940, found 14.5 percent human infection in the South; Harrell and Johnson, 1939, found 2.8 percent human infection in the grain region of the South. Kerr, Jacobs and Cuvillier, 1941, found 16.3 percent human infection along the Eastern seaboard. Gould, 1940, found 20 percent human infection in the Detroit area. Cameron, 1937-40, found 0.75 percent infection in the hogs of eastern Canada, and 0.2 percent infection in the hogs of the middle Canadian region. Koo, 1945, found 1.56 percent hogs infected, and 11 percent rats infected in China (table 1).

Most of the above surveys were based upon findings in routine autopsies. Since routine autopsies are not made in the hospitals of this area, that line of research is not practical. Since the source of human infection is the hog, we have based our study largely upon examinations of pork and pork products. Rats also were examined because of the general prevalence of rats in areas where hogs are fed. It is conceivable that under certain conditions hogs might feed upon rats. Actually, grain fed hogs probably ingest rats or parts of rats infrequently, but since rats have often been shown to harbor this nematode and since our problem was to cover possible sources of infection, we felt justified in examining muscle tissue from these rodents, and reporting our findings in this regard.

Most hogs raised in Central Illinois for market are grain fed. The pork derived from such feeding is of a superior quality and brings a better price. On the other hand, most garbage fed hogs are raised for home consumption.

On the basis of the above, and to obtain a cross section of the hogs slaughtered in this area, a small packing plant just outside of Bloomington, Illinois, was chosen as one source of material. We believe this to be a good choice because there both custom butchering for home consumption and slaughtering of market hogs are handled.

Another possible source of infection studied was pork products, both

cooked and uncooked, sold in this area. Emphasis was placed upon the canned, ready to eat meats.

Rats were the third source of infection studied. Five rat infested areas were chosen, consisting of two farms where it is known that hogs are fed garbage, and three city dumps where garbage is dumped and burned or fed to hogs. These dumps receive the residential garbage from a community of 40,000 people. These areas were chosen because of the marked possibility of infected pork scraps.

It seemed reasonable to assume that if appreciable numbers of trichina were present, they would be found through the study of material from these sources. We fully realize that there are other possible sources of infection, but believe that this study covers a good cross section of the sources in this area.

In the case of hogs, the diaphragms were inspected. In the case of rats, the diaphragm, masseter and gastrocnemius muscles as well as the intestinal content were examined. In the case of pork products, sample portions were inspected.

The detailed examinations were carried out as follows:

1. Microscopic examination for larvae:—A thin slice of the diaphragm or other muscle tissue was placed between two slides and compressed, thus facilitating microscopic study of the specimen.

2. Digestion of muscle tissue with subsequent microscopic examination for larvae:—The tissue was digested by a modified Baermann method. A solution of 0.5 cc. HCl, U.S.P. plus 0.7 gm. pepsin diluted to 100 cc. with water was used. The tissue was cut into small particles and placed into the solution, kept at a constant temperature of 36.5° C., with occasional shaking for a period of four hours. The solution was then centrifuged and the residue examined microscopically.

3. Examination of the intestinal content of rats for adults:—The small intestine was stripped and the contents mixed with 0.85 percent saline solution in a petri dish. This preparation was then examined under a low power, binocular microscope. When suspicious areas were seen, these were placed upon a microscopic slide and studied under a compound microscope.

In cases where immediate examination was not practical, material was stored in a 0.85 percent saline solution or 1-2-3 solution prepared by mixing 1 part 95 percent ethyl alcohol, 2 parts glycerine, and 3 parts water.

A total of thirty-seven hog diaphragms were examined using the direct microscopic method in all cases, and in a majority of cases the digestion method was used as a check. None of the diaphragms were found to be infected.

Thirty-two rats were studied. In all cases the diaphragms were examined by the direct microscopic method. In a majority of cases these findings were checked by the digestion method, using the diaphragm, masseter, and gastrocnemius muscles. An additional check was made through the inspection of the intestinal content for adults. None of these examinations showed trichina to be present.

Ten samples of meat products were studied by the direct micro-

scopic and digestion methods. The products examined were the following: lunch tongue, potted meat, deviled ham, liver spread and sausage. None of these products were found to harbor this parasite.

On the basis of the above findings, we can conclude that there is little, if any, possibility of trichina infection in the human from the sources studied in this Central Illinois Community.

TABLE 1.—COMPARISON OF INCIDENCE OF TRICHINA INFECTION IN REGIONS OF THE WORLD

Organism	Human		Hogs		Rats	
Regions	No.	%+	No.	%+	No.	%+
Cen. Ill.....			37	0	32	0
Detroit Area	500	20				
Middle Canada...			995	.02		
E. Coast....	3000	16.3				
Eastern Canada...			2000	.75		
South.....	4631	14.5				
M. South...	99	2.8				
China.....			320	1.56	47	11

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STUDIES OF THE SEX-ORGANS OF MATING POLYGYRID LANDSNAILS

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This paper is the sequel of earlier studies (Webb, in press, *Naut.*). Aside from describing and figuring the functional form of the sex-organs in mating-anatomies[1] and discussing the mating-behavior, some of the evolutionary and taxonomic implications of the data are mentioned. Also the relationships of the *Euchemotrema* (Archer 1939 a, b) to the typical *Stenotrema* species are somewhat strikingly indicated by the present data, although conclusive results will require the study of many more species.

Supplementary more-detailed data on the methods used in obtaining the observations, matings, and the mating-anatomies, will be found in the Amer. Nat. (Webb, 1947). In regard to the choice of species to be studied, opportunity has been determinative. It has just so happened that specimens of these species have been available for study and sufficient data have accumulated to permit publication. Thus the particular interspecies comparisons which have been occasioned are not as satisfactory as could be desired had specimens of a larger array of *Stenotrema* been available. The much enlarged sketch-figures were drawn from the freshly-obtained a n a t o m i e s; the other figures were from projection-tracings (inversion uncorrected) of unstained toto-mounts preserved in canada balsam (the scale-lines represent 2 mm.)

[1] Definition: the anatomies of snails exhibiting the sex-organs in the extruded, functional condition.

STENOTREMA HUBRICHTI PILSBRY 1940

The material was collected August 23, 1945, about .5-1 mile south of the type locality near Aldridge, Union County, Illinois. About 27 specimens were obtained, half being juveniles; most of the specimens were taken actively crawling about because of rain. Under the over-hanging portions of the cliff-habitat of the species, flat spider-webs yielded several living, aestivating, specimens of this and other snails. The species thrives and breeds readily in captivity, and in the laboratory at least one generation has matured from eggs deposited by the adults. The species was considered a Pleistocene form until its discoverer found some living specimens (Hubricht 1943). All of the available information would seem to indicate that this is either a relict or a suddenly, newly arisen, species.

MATING

A pair of specimens was first noted October 9, 1945 head-on (in the courtship-position) each with dilated genital pore but mating was not noted to occur until the 11th when 4 pairs of specimens previously held in isolation from others of their species were placed together at 4:30 P.M. At 8:05 P.M. a pair was noted in the head-on position; these soon separated. Later, another or the same pair was noted in a head-on

position clinging to the cover-glass; the genital pore of each animal was prominent and dilated, and from one a papilliform body was outthrust intermittently about 1 mm. A few seconds later, the snails shifted their bodies slightly and the sex-organs everted-protruded,[2] simultaneously entwining. The organs were separated and retracted within about a minute. The glimpse of the organs indicated a vermiform penis, but this is not exactly the case.

Courtships continued to be noted, but no more matings were witnessed until the 24th when 6 specimens were placed together experimentally for observations. One of these snails was noted to have a swollen, slightly-protruding genital pore. After a short interval, one specimen was noted crawling suspended from the cover-glass in such direction that it would probably contact a resting animal head-on. Such contact occured. The inactive animal "awakened," protruded-everted the tentacles, and for a short period the two animals remained head-on with the but moderately extended tentacles separated by only a slight distance. A period of head-swaying then ensued in which each animal's superior tentacle is held nearly immobile, but is caused by head movements to oscillate through a short arc opposite the corresponding tentacle of the mate-animal. Seldom is the movement so great as to cause the left tentacle of one snail to move past the right tentacle of the other; instead, the two left tentacles oscillate in apposition, and the two right tentacles oscillate in apposition. The homologous tentacles of each snail thus oscillate from side to side in apposition but seem almost never to brush together or to collide although the intervening space is much less than 1 mm. The inferior tentacles move similarly but less strikingly. During this head-swaying, tentacle-oscillation period, the genital pore of the ex-resting animal became tumid, dilated, and an irregular body became slightly extended therefrom. The crawling snail had progressively shortened its tentacles coincident with a decelerating closer approach; and during the ensuing period of vigorous tentacle-oscillation, its tentacles "arced" in a shorter condition than in the previous period. The genital pore of each animal had by now been completely dilated and both exhibited therefrom a slightly extrudent, irregular, fleshy body. The snails then moved so that the genital pores became nearly contiguous, and the sex-organs were vigorously everted-protruded, entwisting simultaneously. Mating - anatomies were secured by plunging the couple into boiling water. The resultant anatomies, however, were found to be disfigured from the effects of being drawn against the aperture during the fixation process.

The additional matings observed do not differ essentially from that described above. The shifting of the animals' foreparts to bring the genital pores into proximity is sometimes very swiftly accomplished, and possibly may be correlated with the detection by the inferior tentacles of some odor accompanying the dilation of the mate-animal's genital pore.

[2] Since the sub-terminal parts of the penis evert and cause the protrusion of the apical pilaster which forms the penis-capsule and adjacent parts, the organ is both everted and protruded. This is indicated by the compounded term. Only in *S. hirsutum* is the penis solely everted.

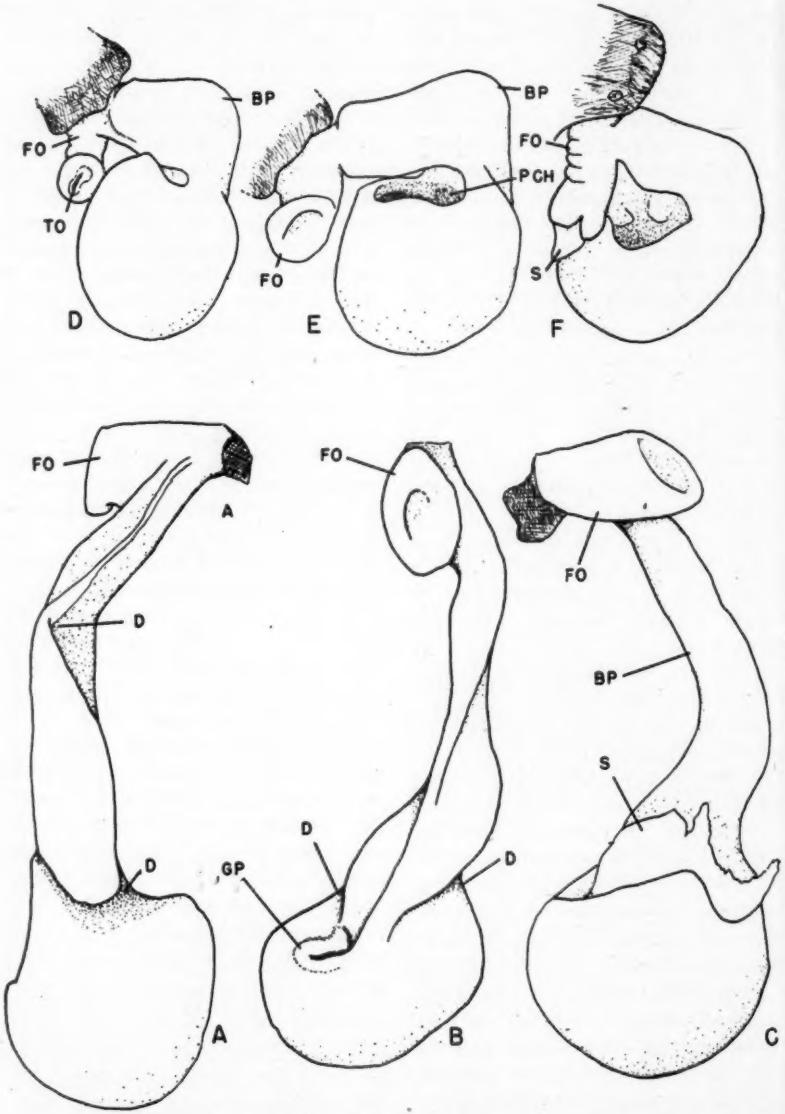

FIG. 1.—*Stenotrema hubrichti* Pilsbry, Aldridge, Illinois. A, B, and C are successive views of a deformed mating-anatomy; D and E are seemingly normal mating-anatomies; F is another specimen. Explanation of symbols: A—atrium BP—basal penis, D—deformation, FO—female-organ, GP—granular patch, PCh—penis chalice, S—semen, TO—terminal orifice of female-organ.

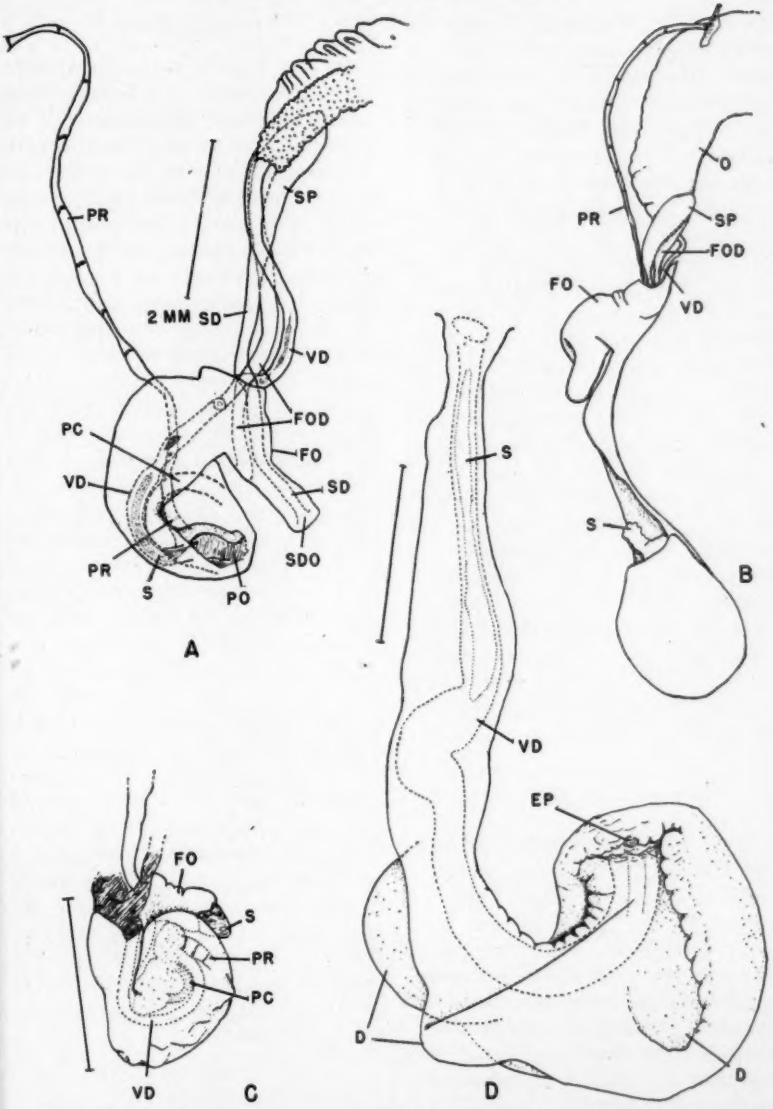

FIG. 2.—A—*Stenotrema monodon* (Rackett) Brown's Lake, Michigan, mating-anatomy; B—*S. hubrichti*, a deformed mating-anatomy showing non-everted parts of the sex-organs; C—normal mating-anatomy; D—*S. hirsutum* (Say) Indiana, mating-anatomy. Explanation of symbols: EP—ejaculatory pore; D—deformation; FO—female-organ; FOD—free oviduct; O—oviduct; PC—penis-capsule; PO—pocket of penis; PR—penis retractor; S—semen; SD—spermathecal duct; SDO—spermathecal duct orifice; SP—spermathecum; VD—vas deferens.

An explosively sudden eversion (or eversion-protrusion) of the sex-organs entwistingly is beginning to appear to be a common characteristic of polygrin landsnails; Gerhardt (1933, 1939) and others have indicated its commonality in limacids—the snail group having the mode of functioning of the sex-organs most like that of our Polygyrinae. These groups may have a greater phylogenetic commonality than has been thought to be the case. The extrusion or bulging of a body from the genital pore prior to the appearance of the entire penis seems not to be of regular occurrence in *S. hubrichti*.

Adequate data on the duration of sex-organ engagement has not been obtained. However, one pair of specimens was noted to maintain the engagement of the sex-organs for 15 seconds. This pair then started another courtship, but further observations could not be conducted at the time. Possibly sperm-transfer had not been effected successfully during the period of contact.

MATING-ANATOMY DATA

Seven mating-anatomies have been available for study.

ATRIUM

The atrium seems more conspicuous in mating-anatomies than in the retracted genitalia and forms about 1 mm. of the basal portion of the sex-organ on which both penis and female-organ[3] depend.

[3] Because of the disconformity in nomenclature and function among the various organs composing the female parts of the sex-organs (the vagina, basal spermathecal duct, and the oviduct may form a single functional organ), the term "female-organ" has been adopted for the female parts of the extruded sex-organs collectively.

FEMALE-ORGAN

In the various mating-anatomies examined, twice the female-organ was found nearly or completely noneverted. The everted female-organ was found to extend .5-1.5 mm. free of the atrium and to be about .5 mm. wide. Structurally the female-organ seems formed entirely by the slightly expanded, evertable vagina and the descended spermathecal duct. None of the anatomies available show other than a terminal orifice, although the orifice of the free oviduct and of the spermathecal duct appear as two pits in this terminal orifice of the female-organ. In this regard the female-organ of this species differs from that of either *fraternum* or *monodon* in which the greater degree of eversion of the spermathecal duct also brings the orifice of the free oviduct to the exterior as a lateral orifice of the female-organ.

The incomplete or noneversion of the female-organ in *hubrichti* is suggestive that the organ is retractable or evertable independently of the penis. Subsequent eversion seems the more probable in view of the fact of penis-entwistment; since, if the female-organ is to occupy the cavity in the penis-tip, this seemingly could not occur until after the completion of the eversion-protrusion and entwistment of the penises.

Semen has been found adhering to the tip of the female-organ in several anatomies.[4]

PENIS

Early in the studies, the frequent deformation of the penis in mating-

[4] No attempts to observe sperm have been made; the material has been identified as seminal because of its similarity to matter in the vas deferens.

anatomies caused some misconception of its true form; however, seemingly undeformed penises (fig. 1 D, E, F, and fig. 2 C) have been obtained by precrushing the shell before plunging the mating specimens into the boiling water. In freshly fixed material, the greatest length of the deformed penis was found to be 10 mm., and the greatest width (which is at the tip) about 2.5 mm. (fig. 2B). Straightening, basal constriction and shell-lip and denticle impressions are some of the penis-deformations noted (fig. 1, A, B, C).

In apparently normal mating-anatomies, the penis is cylindrical with a low, spiral twist of nearly 360 degrees. The penis-tip is rounded and slightly more inflated than the basal penis and bears subterminally a small chalice which is formed by a thickened capsule-like body as in *fraternum* and *monodon*. In *hubrichti* this penis-capsule seems least developed and is about one-fourth the volume of the entire penis. I have not been able to discern clearly an ejaculatory furrow, but such may be present. A part of the rim of the penis-chalice is noticeably more opaque and granular than the surrounding tissues in the fresh material, but this does not show so clearly in the toto-mounts. I have not happened to note a similar opaque-granular area in *monodon* or *fraternum* but perhaps the careful observation of fresh material would reveal it.

Stenotrema monodon (Rackett)

For most of the material, I am indebted to the late Dr. Phil L. Marsh. The material was labeled "N. Shore of Brown's Lake, Jackson Co., Michigan, 10-12-1941." Some observations on matings have also been obtained from specimens collected in the fall of 1945 about Muskelunge Lake, near Warsaw, Kosciusko County, Indiana.

MATING

The Michigan material was received October 16, 1941, and specimens were observed mating on the 17th. In courtship the animals are head-on with the extreme anterior end protruded in a peculiar fashion, as in courting specimens of *fraternum*. This constricted appearance of the extreme anterior parts seems due partly to a tumefaction of the body parts above and posterior to the genital pore. Eventually a dilation of the genital pore occurs and the rest of the courtship and mating resembles that of *fraternum*, with the animals mouthing or gnawing at or about a lobular body protruded from the mate-animal's genital pore. Sperm transfer is accomplished when the penises are suddenly everted-protruded and the female-organ comes to be enveloped by the penis-capsule. (The exact procedure is obscure. It appears more probable that the female-organ is everted into the penis-capsule, than that the capsule engulfs the female-organ.) The disengagement of the organs seems to follow sooner in this species than in *fraternum*. One pair was noted of which one animal pivoted before mating ended the courtship. The mating anatomies of this pair revealed the female-organ of each to be engaged reciprocally in the mate's penis-chalice.

In contrast to *fraternum*, gnawing, biting, and pivoting acts have been observed to occur much more rarely,

but too few observations are at hand to justify the conclusion that a difference in behavior exists.

MATING-ANATOMY DATA

Only two pairs of mating-anatomies have been available for study, although the extruded organs of several additional pairs have been momentarily glimpsed in life (fig. 2A.).

ATRIUM

This is not a sharply differentiated part of the extruded sex-organs, but presumably forms the parts adjacent to the genital pore area.

FEMALE-ORGAN

This appears slimmer and without the low annulations exhibited in *fraternum* and does not project from beneath a low fold as in that species; both a terminal orifice (spermathecal duct) and a lateral orifice are present.

PENIS

This is similar in general form to that of *fraternum* but differs in the following details: it is more ellipsoid and less globular in shape, bears a smaller penis-capsule forming a smaller penis-chalice, and lacks the slight ridge overhanging the female-organ and basal penis. The internal structure of the penis-chalice in *monodon* also differs in having a wide, shelf-like pocket instead of a sinuous, ejaculatory fissure. The orifice of the penis-chalice is triangular or elongate in *monodon* whereas it is rounded in *fraternum*.

STENOTREMA HIRSUTUM (SAY)

Most of the material was collected in Indiana in 1939 or 1940, presumably near Indianapolis. While the shells of some of the specimens seem identical with the material from Indianapolis which Pilsbry (1940, p. 658, fig. 409a) designates as *S. stenotrema* (Pfeiffer), I am not convinced that a central Indiana population exists which is specifically separable from the local *hirsutum*. Some will prefer to regard the material studied, however, as a mixture of *hirsutum* and *stenotrema*. One mating and a pair of mating-anatomies were obtained from material collected on the hillsides of Big Bureau Creek, within 2 miles upstream of the route 26 bridge near Princeton, Illinois.

MATING

The first complete observations on mating were made November 27, 1940, when specimens were noted crawling about suspended from the cage cover-glass. The specimens formed courting couples which separated and reformed with new or old partners. The specimens crawled actively, waving the tentacles, and frequently pivoting. Prior to mating, two specimens were noted head-on with the genital pore dilated and forming a curved swelling. When the edge of the swelling of one snail touched that of the other, the penises were reciprocally everted entwiningly.

In the pair of Bureau County specimens observed October 22, 1945 (uncontroversially *hirsutum*), the courtship started with a circling movement of one animal following the tail of the other. After being in a head-on position, pivoting ensued and the animals discontinued activi-

ties. Shortly thereafter, another or the same pair were noted in courtship. In these a reciprocal spiraliform movement occurred clockwise (the animals were suspended from the cage cover-glass) such that the head of one animal was opposite the non-genital pore side of the other, and the bodies were bent nearly at a right angle. Pivoting by both animals followed. The snails failed to rejoin head-on but resumed the spiraliform, reciprocal circling as before. One animal pivoted (possibly because of a mild gnawing by the other against the side of the foot or body) and the genital pore was seen to be slightly prominent as a pimple-like swelling. The specimens continued these maneuvers until they happened to rejoin head-on, each with the genital-pore bulging convexly. As soon as the animals were close enough together to contact with the fore parts of the genital swelling of the mate-animal, the penises everted entwiningly; the animals were still suspended from the cover-glass by the foot as before. Exclusive of the first, interrupted courtship, the courtship is estimated to have lasted about half-an-hour. Biting was not noted, but a gentle rasping on the side of the foot may have occurred. These specimens had been kept in isolation from others of the species until they were placed together for possible matings.

MATING-ANATOMY DATA

None of the four mating-anatomies obtained probably have been free of the deformations which result from the wedgement of the extruded sex-organs against the aperture during fixation (fig. 2D).

ATRIUM

This is continuous with the basal part of the penis and is not discernable from it.

FEMALE-ORGAN

An everted female-organ has not been found in any mating-anatomy. Other evidence of the nonevertability of this organ is the absence of a thickened vaginal duct, basal spermathecal duct, and free oviduct; in *monodon*, *fraternum*, and *hubrichti* these ducts are noticeably thickened and muscular in the retracted organs. Some other Polygyrinae are known to have nonevertable female-organs, as *Mesodon thyroidus* and *M. clevatus*.

PENIS

Despite more or less disfigurement, the essential form of the penis seems to be that of a tapering, somewhat flatsided sac bearing the ejaculatory pore distally. The pore opens to the exterior centrally on the tip of the penis. A strand of seminal matter protrudes from the pore in one anatomy. No capsule, chalice, or comparable structures are present. The entire penis has a curved or spiraliform twist. Were the recurved penis-tip to become fused with the midportion, a condition somewhat analogous to that in *hubrichti* would result, except that a penis-capsule and a female-organ would yet be lacking.

Conclusions

In the *Euchemotrema* (subgenus) studied, all have a similar type of mating-behavior. Pivoting is not a frequent and prominent part of the

mating-actions; this probably is due to the infrequency of biting or other extremely stimulative actions, and to the slow head-on approach utilized which prevents the attainment of positions unfavorable to mating. *S. hubrichti* seems to have the most quiet type of mating-behavior with seemingly the complete absence of biting or gnawing actions, and is characterized by the elaborateness of the head-arcing process in courtship.

In the *Stenotrema* (subgenus) studied, *hirsutum* and/or *stenotrema*, the behavior differs from the preceding group in the greater activity of the animals with the greater part of the courtship period being occupied with rotations, spiraliform-movements, and pivoting, rather than a very slow, head-on approach.

From the standpoint of sex-organ anatomy, *fraternum, monodon,* and *hubrichti* seem to exhibit modifications of a common basic type. The slight specific differences between *monodon* and *fraternum* anatomically may be useful in varietal and species diagnosis, although some of the many varieties of these two species may be found to exhibit transitional types. Phylogenetically *hubrichti* would seem to be the most divergent of the three species. The apical, globular pilaster noted by Archer as characterizing the *Euchemotrema* is the seeming homologue of the penis-capsule, and would seem to be a more important criterion than penis-length. In the lack of female-organ and penis-capsule, *hirsutum* (subgenus *Stenotrema*) would seem to be rather divergent from the preceding.

The sex-organ structure of these species seems to illustrate possible sex-organ barriers to panmixy. Thus *monodon* and *fraternum* might be expected to cross-mate, but *hubrichti,* because of entwistment, would seem apomixic to these other two species. In regard to *hirsutum, hubrichti* might be panmixic anatomically since an entwistment of penises between these two species conceivably might accomplish sperm-transfer; however, the differences in mating-behavior would probably prevent the courtship from arriving at the entwistment stage. The present data strongly suggest the presence of sex-organ barriers and mating-behavior barriers to panmixy to varying degrees within the polygrin genus *Stenotrema.* Such barriers in all likelihood have influenced and continue to influence the evolution and speciation of these snails.

Summary

1. The form of the sex-organs in the extended, functional condition, the mating behavior, and the evolutionary significance of the data are given for *Stenotrema hirsutum* (Say), *S. hubrichti* Pilsbry, and *S. monodon* (Rackett) in comparison to *S. fraternum* (Say).

2. The form of the sex-organs of *monodon* appear essentially as in *fraternum,* but the penis is more eliptical, the penis-capsule smaller, and the female-organ slimmer and less ornate. *Stenotrema hubrichti* differs from *monodon* and *fraternum* in having a stalked penis, a more-reduced penis-capsule, and lateral-poreless, much smaller female-organ. The sex-organ of *hirsutum* differs markedly from that of the preceding species in lacking a female-organ, and in having a simpler, tubular-

spiraliform penis which has a terminal ejaculatory pore, but no capsule or chalice.

3. The mating-behavior of *monodon* is essentially like that of *fraternum*, but *hubrichti* differs slightly in the exaggeration given the arcing process of the head-and-tentacles, and in the absence of biting during mating. Almost constant maneuvering with fleeting periods of the head-on position characterizes the mating-behavior of *hirsutum*.

4. Sperm-transfer in *monodon* and *fraternum* is accomplished by the sudden eversion-protrusion of the penis and deposition of seminal material on the everted female-organ which occupies the penis-chalice. In *hubrichti* an entwistment of the everting-protruding penises occurs, but it appears probable that otherwise sperm-tranfer is accomplished similarly. In *hirsutum* the lack of a female-organ modifies sperm-transfer in necessitating the use of the penis also in securing the exchanged or shared semen.

5. Evolutionarily, *fraternum* and *monodon* seem least likely of the species studied to have an effective sex-organ difference barrier to panmixy; *hubrichti* does seem to have a sex-organ difference barrier to panmixy with the preceding, and also possibly with *hirsutum*. While seemingly apomixic to *monodon* and *fraternum*, possibly *hirsutum* has only a behavior barrier to panmixy with *hubrichti*.

6. The present data indicate that sex-organ differences affecting panmixy probably exist among the species of the polygyrin genus *Stenotrema*, and in all likelihood have influenced the evolution and speciation of these snails.

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ADDITIONAL RECORDS OF ILLINOIS MAMMALS

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The records of distribution of mammals of Illinois were last summarized by Necker and Hatfield in 1941. Since that time relatively few records of Illinois mammals have appeared and these data are scattered through the literature.

Specimens reported by Koestner (1941a and b; 1942) had been recorded by Necker and Hatfield through correspondence with Koestner. Goodnight and Koestner (1942) recorded mammals found in the general area of a quadrat study near Seymour, Champaign County; however, this list included no new county records, with the possible exception of a sight record of the red fox.

Bole and Moulthrop (1942) cited records which were new for the short-tailed shrew, *Blarina brevicauda*, from Bloomington, McLean County; the prairie meadow mouse, *Microtus ochrogaster*, from Ozark and Reevesville, Johnson County, and from Bloomington; and the lemming vole, *Synaptomys cooperi*, from Bloomington.

Mohr discussed the distribution of Franklin's ground squirrel, the thirteen-lined ground squirrel, the woodchuck (1943), and the prairie mole and pocket gopher (1946) but did not cite actual specimens. Mohr's discussion (1941) of the distribution of Illinois mammals was without citation of actual specimens.

This paper is an effort to summarize records from collections made since 1941, as well as a few records prior to that time which were not cited by Necker and Hatfield. These records were obtained from lists of collections supplied by the Chicago Natural History Museum, the Museum of Zoology of the University of Michigan, and the Department of Zoology of the University of Wisconsin; from examination by the writer of the collections of the Illinois State Natural History Survey, Normal State University, and the University of Illinois Natural History Museum; from the writer's collection; and from certain records obtained from the literature since 1941.

I should like to express my appreciation for the cooperation of the following institutions and more specifically to individuals at these museums: D. F. Hoffmeister, University of Illinois Natural History Museum; C. O. Mohr, Illinois State Natural History Survey; C. C. Sanborn, Chicago Natural History Museum; H. K. Gloyd, Chicago Academy of Sciences; W. H. Burt, Museum of Zoology, University of Michigan; Orlando Park, Department of Zoology, Northwestern University; J. T. Emlen, Jr., Department of Zoology, University of Wisconsin; and M. R. Lamkey, Normal State University, Normal, Illinois.

The collection of the State Natural History Survey included many unpublished records from recent collections, made largely by C. O. Mohr; and many old specimens either not specifically cited by Wood (1910) or not recorded in literature

at all. These latter groups contain specimens collected by Wood, Gross, and others and date back to 1877. The material at Normal University consists largely of old collections by the Natural History Survey when located at Normal and of remnants of the Major J. W. Powell collection.

There have been few literature citations of records of mammals collected from the western part of Illinois. The following list records for that part of the state many of the common mammals, as well as more noteworthy records such as the lemming vole, *Synaptomys cooperi*, and the eastern meadow mouse, *Microtus pennsylvanicus*.

The Carolina shrew, *Sorex longirostris longirostris*, has heretofore been reported only for the southernmost portion of Illinois, in Alexander and Johnson counties, with the exception of a possible record by Wood for Pistakee Bay, McHenry County. In 1946 Mohr obtained a specimen from Fox Ridge State Park in Coles County. This record extends the range of this southern shrew to at least central Illinois.

On the basis of literature citing specimens actually on deposit in museums, the cinereous shrew, *Sorex cinereus cinereus*, has been recorded only from northern Illinois in Cook, Lake, and Kankakee counties. Specific reference is made in the following list to a specimen collected at Normal, McLean County, now on deposit at the Illinois State Natural History Survey. This specimen was collected in 1877 and probably formed the basis of the McLean County record of Wood.

Existing records of the lemming vole, *Synaptomys cooperi*, have been restricted to Crawford and Hardin counties to the south and Vermilion and Champaign counties in east central Illinois. In the fall and winter of 1946 trapping for this microtine was stimulated at the University of Illinois by the capture of two specimens near LeRoy, McLean County, by D. F. Hoffmeister; two specimens at Kickapoo State Park, Vermilion County, by the writer; one specimen four miles east of Urbana by Dean Ecke, a University of Illinois student; and the discovery in a quadrat study by D. G. Allison and the writer of a high population of *Synaptomys* in the extensive undisturbed blue-grass areas of the Allerton Tract, five and one-half miles west of Monticello, Illinois. Hoffmeister (1947) continued study of the *Synaptomys* population on the Allerton Tract. As a result of this large population of the lemming vole, the number of specimens in the University of Illinois Natural History Museum is still increasing. In addition to these collections, recent specimens obtained by Mohr and by Sanborn and Eigsti, Chicago Natural History Museum, indicate a probable statewide, although spotty, distribution of this vole.

The distribution of the eastern meadow mouse, *Microtus pennsylvanicus pennsylvanicus* has been recorded largely as restricted to northern Illinois. Through no fault of Necker and Hatfield, two *Synaptomys cooperi* from Muncie, Vermilion County, were reported (1941) as *M. pennsylvanicus*. Mohr pointed out this discrepancy, and I have verified that the report is in error by examination

of the two specimens in alcohol on file at the Natural History Survey. In April 1947, six *M. pennsylvanicus* were trapped in a blue-grass pasture, which has been ungrazed for over seven years, two miles southeast of Good Hope, McDonough County. In this area *M. ochrogaster* was trapped at the same time and in approximately equal numbers. A record of *M. pennsylvanicus* for Warren County was obtained from the Natural History Survey collection; the specimen is No. 38328 (skull only) and was collected February 12, 1908, at Monmouth. In addition, three specimens in alcohol at the Survey were collected at Normal in 1877 and 1878 and probably form the basis of Wood's McLean County records.

In general, the occurence of *M. pennsylvanicus* in Illinois appears to be nearly statewide, with the possible exclusion of the southern portion of the state. However, due to the early dates of many of the records and since present capture in central Illinois is restricted almost entirely to long undisturbed areas, the present distribution in Illinois is probably almost as spotty as is indicated by the actual records.

The restricting effects of agriculture and other efforts of man which have altered the natural prairie and forest-edge of the state is evident in the above mentioned distribution of *M. pennsylvanicus* and *S. cooperi*. This is probably more graphically seen in examination of records for the meadow jumping mouse, *Zapus hudsonius hudsonius*. Wood had no specimens of the jumping mouse and stated that it was apparently much rarer in the state than formerly, and perhaps on the verge of extinction. Necker and Hatfield cite specimens from Cook, Jackson, Jo Daviess, Kane, Lake, and Marshall counties. From Wood's statements and those of Mohr (1941) and from information gained from elderly farmers, it is inferred that even in its southern range in Illinois, the jumping mouse was once not uncommon. This is somewhat borne out by the discovery of two specimens at Normal University, one from McLean County and one from nearby Woodford County, collected in 1875 and 1879 respectively. To these older records may be added a sight record by the writer in 1929 for McDonough County. Also, a jumping mouse was captured in a Sherman live trap on a population study grid-quadrat of the writer's at Kickapoo State Park, Vermilion County, in April, 1941. This particular area had been strip-mined approximately thirty years earlier and had received little further disturbance from man since that time.

Additional Records of Mammals in Illinois

An effort has been made to be extremely conservative in listing these records of mammals for Illinois, and in many cases subspecies have not been mentioned. In some cases this is due to unsettled taxonomy of a particular genus and in others to the probability of the specimens being intergrades which have not been sufficiently studied to permit subspecific determinations. In listing the localities the general plan of that used by Necker and Hatfield is followed. In addition, the number of specimens on deposit is listed and in the cases in which a specimen is not

made up as study skin and skull, the condition of the specimen is indicated. The accession numbers, dates, and collectors are given, when available, for records of especial interest. The list of localities includes specimens in collections designated as follows:

ClM—Cleveland Museum of Natural History, Cleveland, Ohio
CNHM—Chicago Natural History Museum (Field Museum)
INHS—Illinois State Natural History Survey, Urbana, Illinois
M—Museum of Zoology, University of Michigan
N—Normal State University, Normal, Illinois
RMW—R. M. Wetzel, University of Illinois, Champaign, Illinois
UI—Natural History Museum, University of Illinois
UW—Department of Zoology, University of Wisconsin, Madison, Wisconsin.

Didelphis virginiana virginiana Kerr. Virginia Opossum.
Coles—Mattoon, 1 INHS. *Cumberland*—Greenup, 1 (skull only) INHS. *Fayette*—Farina, 1 UW. *Fulton*—Summum, 1 (skull only) INHS. *Jackson*—Grand Tower, 1 (skull only) INHS. *Union*—Wolf Lake, 1 (skull only) INHS.

Sorex cinereus cinereus Kerr. Cinereous Shrew.
Cook—Park Ridge, 1 (alc) INHS. *Lake*—Lake Zurich, 1 (alc) INHS. *McLean*—Normal, 1 (alc) INHS (No. 37192—Nov. 6, 1877).

Sorex longirostris longirostris Bachman. Carolina Shrew.
Coles—Fox Ridge St. Park, 1 (alc) INHS (coll. C. O. Mohr—Oct. 12, 1946).

Blarina brevicauda (Say) subspecies. Short-tailed Shrew.
Bureau—Ohio, 1 UI. *Henry*—Geneseo, 3 (alc) INHS. *LaSalle*—Starved Rock St. Park, 1 INHS. *McLean*—Bloomington, 26 Cl M (Bole & Moulthrop, 1942); Normal, 2 N, 8 (alc) INHS. *McHenry*—near Pistakee Bay, 5 (alc) INHS (Nos. 38262-4, 38275, 38277—Nov., 1907). *Stephenson*—Dakota, 1 (alc) INHS. *Vermilion*—Kickapoo St. Park, 1 CNHM, 1 RMW. *Warren*—Monmouth, 1 (alc) INHS (coll. F. E. Wood—Jan. 25, 1908).

Cryptotis parva (Say) subspecies Small Short-tailed Shrew.
Coles—Charleston, 1 INHS (No. 38241—Dec., 1903). *Iroquois*—Onarga, 1 (alc) INHS; Thawville, 1 (alc) INHS. *Mason*—Havana, 2 INHS (No. 38241— Oct. 30, 1907, & 1 alc). *Piatt*—Allerton Tract, Monticello, 2 (1 whole skelton) UI.

Myotis lucifugus lucifugus (LeConte). Little Brown Bat.
Adams—Quincy, 1 (alc) INHS. *Calhoun*—Pere Marquette St. Park, 1 (alc) INHS. *LaSalle*—Starved Rock St. Park, 1 (alc) INHS. *Monroe*—Burksville, 1 (alc) INHS. *Schuyler*—Beardstown, 1 (alc) INHS.

Lasionycteris noctivagans (LeConte). Silver-haired Bat.
Ford—Gibson City, 1 (alc) INHS.

Eptesicus fuscus fuscus (Beauvois). Big Brown Bat.
LaSalle—Peru, 7 CNHM.

Lasiurus borealis borealis (Müller). Red Bat.
Calhoun—Pere Marquette St. Park, 1 (alc) INHS. *Cook*—Maywood, 3 (alc) INHS. *LaSalle*—Starved Rock St. Park, 1 (alc) INHS. *Massac*—New Columbia, 2 (alc) INHS. *McLean*—Normal, 7 (alc) INHS. *Pope*—Bay City, 1 (alc) INHS; Herod, 1 (alc) INHS.

Nycticeius humeralis (Rafinesque). Rafinesque's Bat.
McLean—Bloomington, M; Normal, 1 (alc) INHS.

Procyon lotor (Linnaeus) subspecies. Raccoon.
Champaign—Urbana, 1 (skull only) RMW. *Cumberland*—Greenup, 1 (skull only) INHS. *Lake*—Fox Lake, 1 INHS. *Massac*—Metropolis, 1 (skull only) INHS.

Mustela frenata noveboracensis (Emmons). Long-tailed Weasel.
Livingston—Dwight, 1 (pelt only) INHS. *McLean*—Normal, 1 INHS. *Winnebago*—Rockford, 1 INHS.

Mustela vison Schreber. Mink.
Alexander—Olive Branch, 1 (skull only) INHS.

Mephitis mephitis avia Bangs. Striped Skunk.
Massac—Metropolis, 1 (skull only) INHS. *McDonough*—Good Hope, 1 RMW. *Pike*—Griggsville, 3 (pelts only) INHS.

Vulpes fulva (Desmarest). Red Fox.
Douglas—Arcola, 3 (skulls only) INHS; Reynoldsville, 1 (skull only) INHS. *Livingston*—Dwight, 2 (skulls only) INHS; Manville, 3

(skulls only) INHS. *Mason*—Bath, 1 (skull only) INHS. *Piatt*—Allerton Tract, Monticello, 1 (skull only) RMW. *Pike*—Griggsville, 2 (skulls only) INHS.

Urocyon cinereoargenteus cinereoargenteus (Schreber). Gray Fox.
Mason—Bath, 1 INHS; Havana, 1 (skull only) INHS. *Pike*—Griggsville, 1 (skull only) INHS.

Marmota monax monax (Linnaeus). Woodchuck.
Massac—New Columbia, 1 (skull only) INHS. *Ogle*—Flag Center, 1 (skull only) INHS. *Pike*—Griggsville, 1 (pelt only) INHS. *Union*—Wolf Lake, 2 CNHM. *Vermilion*—Fairmont, 1 (skull only) RMW.

Citellus tridecemlineatus tridecemlineatus (Mitchill). Thirteen-lined Ground Squirrel.
Macon—Decatur, M.

Citellus franklinii (Sabine). Franklin's Ground Squirrel.
Douglas—Arcola, 1 INHS. *Ogle*—Oregon, 1 (skull only) INHS.

Tamias striatus griseus Mearns. Eastern Chipmunk.
DeKalb—Waterman, 1 UI. *Jackson*—Murphysboro, 1 CNHM. *Lake*—Antioch, 1 (alc) INHS. Possibly the specimen from Murphysboro is referable to *T. striatus ohionensis* Bole and Moulthrop.

Sciurus carolinensis Gmelin subspecies. Gray Squirrel.
Carroll—Thomson, 1 (pelt only) INHS. *Fayette*—Farina, 1 UW. *Jo Daviess*—Galena, 1 (pelt only) INHS. *Union*—Wolf Lake, 1 (pelt only) INHS.

Sciurus niger rufiventer (Geoffroy). Fox Squirrel.
Carroll—Thomson, 1 (pelt only) INHS. *Logan*—San Jose (east), M. *Marshall*—Rutland, 1 INHS. *Massac*—New Columbia, 1 (skull only) INHS. *McLean*—Hudson, 1 N. *Pike*—Griggsville, 2 INHS; Valley City, 1 (pelt only) INHS. *Sangamon*—Lanesville, 1 (pelt only) INHS. *Union*—Wolf Lake, 2 (pelts only) INHS. *Vermilion*—Muncie, 1 (skull only) INHS. *Will*—Wheatland Tp., M.

Peromyscus maniculatus bairdii (Hoy and Kennicott). Prairie Deer Mouse.
Calhoun—Pere Marquette St. Park, 1 (alc) INHS. *Coles*—Charleston, 4 (alc) INHS (Nos. 37977, 39666, 39668, 39670—1908). *Jo Daviess*—Galena, 2 (alc) INHS. *Kankakee*—Bourbonnais, 2 (alc) INHS. *Marion*—Salem, 1 INHS. *Mason*—7 (alc) INHS. *McDonough*—Good Hope, 1 RMW. *McHenry*—near Pistakee Bay, 4 (alc) INHS. *McLean*—Normal, 1 (alc) INHS (No. 37195—May 6, 1876). *Vermilion*—Kickapoo St. Park, 4 RMW. *Warren*—Monmouth, 5 (alc) INHS.

Peromyscus leucopus leucopus (Rafinesque). White-footed Mouse.
Jackson—Carbondale, 4 CNHM.

Peromyscus leucopus noveboracensis (Fischer). White-footed Mouse.
Carroll—Thomson, 1 INHS. *Coles*—Charleston, 1 INHS. *Fulton*—Duck Island, 8 (1 w/skull only, 1 w/o skull) UI. *Madison*—Alton, M. *Mason*—Havana, 1 INHS; 1 CNHM. *Ogle*—White Pines St. Park, 2 RMW.

Neotoma floridana illinoensis Howell. Illinois Wood Rat.
Alexander—Horseshoe Lake (Olive Branch), 1 INHS.

Synaptomys cooperi Baird. Lemming Vole.
Champaign—Urbana, 2 INHS (No. 37969 alc & No. 37970—March 7, 1908), 1 UI (Nov., 1946). *Fulton*—Vermont, 1 (alc) INHS (Oct. 24, 1946). *McLean*—Bloomington, 2 ClM (Bole & Moulthrop, 1942; includes type of *S. c. saturatus*); LeRoy, 2 UI (Nov., 1946). *Piatt*—Allerton Tract, Monticello, 18 RMW (Nov., 1946 & Feb., 1947, 9 w/skulls only), 12 UI (Nov., 1946 & Feb., 1947). *Richland*—Olney, 20 (skulls only—from owl's nest) INHS (1934). *Vermilion*—Muncie, 2 (alc) INHS (June, 1936. Reported by Necker & Hatfield, 1941, as *Microtus pennsylvanicus*); Kickapoo St. Park, 4 CNHM (July 21, 1942), 2 RMW (Nov. 7, 1946). *Sangamon*—Auburn, 1 RMW.

Microtus pennsylvanicus pennsylvanicus (Ord). Eastern Meadow Mouse.
Douglas—Arcola, 1 INHS. *Kane*—Sugar Grove, M. *Lake*—Waucanda, INHS (fragments of skulls). *McDonough*—Good Hope, 6 RMW (April 6, 1947). *McHenry*—tamarack swamp near Pistakee Bay, 2 (alc) INHS (Nos. 38290, 38291—Nov., 1907). *McLean*—Normal, 3 (alc) INHS (Nos. 37183, 37194, 37863—1877 & 1878). *Warren*—Monmouth, 1 (skull only) INHS (No. 38328—Feb. 12, 1908).

Microtus ochrogaster (Wagner). Yellow-bellied Meadow Mouse.
Adams—Lima, 2 INHS. *Cook*—Des Plaines, 3 UI. *Hancock*—Hamilton, 1 N (Jan., 1884). *Iroquois*—Onarga, 1 (alc) INHS. *Jasper*—Hunt, 2 (1

alc) INHS. *Johnson*—Ozark, 2 CNHM (Bole & Moulthrop, 1942); Reevesville, 2 CNHM (Bole & Moulthrop, 1942). *Madison*—Godfrey, 1 (skull only) INHS. *McDonough*—Good Hope, 4 RMW. *McLean*—Bloomington, 9 Cl M (Bole & Moulthrop, 1942); Normal, 2 N; LeRoy, 1 UI. *Piatt*—Allerton Tract, Monticello, 2 UI; Monticello, 1 (alc) INHS. *Putnam*—Putnam, 1 (alc) INHS. *Warren*—Swan Creek, 1 RMW. *Woodford*—Eureka, 3 UI.

Pitymys pinetorum (LeConte). Pine Mouse.

Piatt—Allerton Tract, Monticello, 1 UI. *Richland*—Olney, 1 (alc) INHS.

Zapus hudsonius hudsonius (Zimmermann). Meadow Jumping Mouse.

McLean—no locality, 1 N (1875). *Vermilion*—Kickapoo St. Park, 1 RMW (April, 1941). *Woodford*—Kappa, 1 N (May 24, 1879).

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6. Special Banking Practices in a Suburban Community in Illinois: JAMES HOCHSTETTLER, Wheaton College, Wheaton.
7. Spectrophotometric Determination of Ascorbic Acid in Blood: PATRICIA BANN, LeClerc College, Belleville.
8. Spectrophotometric Determination of Copper and Iron in Blood: RUTHMARY POELKER, LeClerc College, Belleville.
9. A Study of the Rh Factor in the Blood: DOLORES BARTA, LeClerc College, Belleville.
10. Hydrogen Ion Concentration—A Controlling Factor in the Staining Properties of Bacteria: BETTY ANN BURNS, LeClerc College, Belleville.
11. Spectrophotometric Determination of Beta-carotene and Vitamin A in the Blood: ANNA DEAN BREYEL, LeClerc College, Belleville.
12. Key to the Genera of Agaricaceae: MARY DIEL and VERA SCHERER, Eastern Illinois State Teachers College, Charleston.
13. Color Discrimination in Fishes: RICHARD H. PICL, University of Illinois, Urbana.
14. Choice of Background Color in Fishes: ROBERT ASHBY, BILLY MESTAL, and WARD MOORE, University of Illinois, Urbana.
15. Distribution of Mollusca in the Salt Fork of the Big Vermilion River with Special Reference to Pollution: GLENN R. WEBB, University of Illinois, Urbana.
16. Comparative Study of Nuclei of some Cryptogams and Phanaerogams in both Living and Fixed Condition: PATRICIA A. CORCORAN and PATRICIA M. BRANIGAN, Mundelein College, Chicago.

MEMORIAL

ALBERT EDWARD EDGECOMBE
1897-1945

The sudden death on March 30, 1945, of Albert Edward Edgecombe at the age of forty-eight cut short the life of a man whose devotion to study and research had reached the stage where his accumulated knowledge and techniques would have resulted in maximal productiveness. He was an Englishman by birth, spent over half of his life in Canada, and became an American citizen in 1935. He was an associate professor of botany at Northwestern University at the time of his death. His research activities were largely in the field of mycology.

Albert Edward Edgecombe was born in Devonshire, England, on February 5, 1897, and succumbed to a cerebral hemorrhage at his home in Wilmette, Illinois, on March 30, 1945. He was the son of Samuel and Frances (Pennell) Edgecombe, coming to Canada with his parents when three years old. He taught in the secondary schools of Canada for several years, and served as a field agent of the Presbyterian Church in British Columbia. He was graduated with honors from Queens University, Ontario, in 1923 and received the degree of Master of Arts from the same institution two years later. He then entered the graduate school of the University of Chicago, completing the work for the doctorate in 1929. From the Chicago Law School he received the LL.B and J.D. degrees in 1934.

Edgecombe was a fellow of the American Association for the Advancement of Science, a charter member of the Mycological Society of America, and a member of Phytopathological Society, Botanical Society, American Association of University Professors, Sigma Xi, Phi Alpha Delta, and the Illinois State Academy of Science.

He married Sara Roberta Mohn of Pottstown, Pennsylvania, on November 23, 1939. His widow and two children, Phyllis and David, together with one brother living in Canada, survive him.

Edgecombe was retiring, shy, and modest to the point of self-effacement. His qualities of friendliness, generosity, and affection were reserved for his family and his intimate friends He loved the quiet of his home and the seclusion of his laboratory. He was an indefatigable worker, his interests ranged from poetry to medicine, and he died as he had wanted to live: quietly and with a minimum of disturbance to his fellow man.

HANFORD TIFFANY
Northwestern University

ACADEMY BUSINESS

SECRETARY'S REPORT ON THE BUSINESS OF THE ILLINOIS STATE ACADEMY OF SCIENCE

For the Year May 4, 1946 to May 3, 1947

Compiled by HURST H. SHOEMAKER, *Secretary*

During the past year the Illinois State Academy of Science has had a rapid recovery from the adverse effects of the war. There was a record attendance of more than 700 persons at the annual meeting at which a large number of papers was presented. There were 112 papers presented in the nine regular sections and 31 in the two collegiate sections. The rapid growth of the collegiate section made the two sections necessary and suggests the need for more next year. At the annual banquet on May 2, Gustav A. Swanson spoke on Wildlife Research—Some Recent Advances. The committee on research grants reported $408.00 of the AAAS grant fund awarded as follows: To C. W. Bennett, Western Illinois State Teachers College, Macomb, $75 to make it possible to carry out work in microanalysis of 1-nitro-fluorine and 1-nitro-penanthrene. To W. M. Reid, Monmouth College, Monmouth, $75 for continuation of research on animal parasites. To H. F. Thut, Eastern Illinois State Teachers College, Charleston, $50 for research with hybrid ferns. To Sister M. Joan, College of St. Francis, Joliet, $83 for purchase of supplies for investigating possible chromatographic absorption in leafy vegetables. To P. E. Martin, Wheaton College, Wheaton, $125 to apply on purchase of equipment for continuing investigations of dynamic electrolysis.

Two committees were appointed to cooperate with Science Clubs of America in Science Talents Search program in awarding 21 college and university scholarships to high school seniors.

1. COUNCIL MEETINGS

Four council meetings were held during the year. The first one was held at Bloomington on May 4, 1946, with A. E. Emerson presiding. Possible meeting places for the next annual meeting were discussed but decision was postponed.

The second council meeting was held in Urbana, November 23, 1946, with L. R. Tehon presiding and seventeen in attendance. Reports were presented from the treasurer, secretary, editor, librarian, Junior Academy chairman, collegiate section coordinator, and committees on the Illinois Journal of Science, the research development project, and the State Museum building. Peoria was chosen as the place for the 1947 annual meeting and Dr. W. W. Grimm was elected second vice-president in charge of local arrangements. President Tehon outlined the responsibilities of the section chairmen. A resolution presenting the urgent need for a State Museum building was unanimously passed. It was decided to extend the Junior Academy of Science to include the grade school level. The Agriculture Section was discontinued as a result of the vote of this section on May 3, 1946; this section was merged with other sections, according with the major interests of the various members.

At the third council meeting, held at Urbana, January 25, 1947, reports from officers and committees were presented. The committee on the establishment of a proposed Illinois Journal of Science was discontinued, following the resignation of the chairman, for the following reasons: (1) The Academy is not financially able to back the venture; (2) the field of state science is too narrow to represent more than a portion of the interests of the membership, and (3) all the good research now being performed in the state seems to have an adequate publication outlet. After discussion, a proposal to allow members to become life members after a certain number of years was dropped. Mrs. Audrey Hill Lindsey was introduced to the group as the new supervisor of the "Science on the Air" program.

At the fourth council meeting, held in Peoria, May 1, 1947, there were 23 pres-

ent. Vice-president Stover presided. The local arrangements committee with section chairmen and officers made final arrangements for the annual meeting. Reports were made by the AAAS delegate, the Junior Academy chairman, and the committees on conservation and living memorials. A motion was passed to learn the negotiable value of the real estate bonds owned by the Academy, to be reported at the next meeting. Plans for the establishment of an incorporated Academy foundation were discussed.

2. GENERAL BUSINESS MEETING

A short preliminary business meeting was held at 9:30 a.m., May 3, 1947, at which appointments were made to committees on nominations, resolutions and auditing. At the second business meeting held at 5:00 p.m., reports were heard from the treasurer and committees on auditing, resolutions, necrology, membership and science talent search. The Academy was invited to hold its next meeting in Harrisburg.

3. REPORTS OF THE TREASURER AND COMMITTEE ON AUDITING

(a) Report of Treasurer For the Year May 1, 1946 to April 30, 1947

Receipts

Balance on hand April 30, 1946		$ 1,602.79
Dues and initiation fees:		
Annual members	759.10	
Affiliated societies	1.00	
		760.10
Interest on Forbes and Meyer real estate		18.00
Interest from U. S. Savings bonds		5.00
Libraries		1.00
Research grant by the AAAS		75.00
Junior Academy:		
Dues	7.00	
Sustaining memberships	300.00	
		307.00
Total Receipts		$ 2,768.89

Expenditures

Council dinner	25.60
Speakers' expenses	50.00
Officers' expenses	10.00
Section Chairmen expenses	47.11
Postage, Treasurer's office	24.95
Expenses of Secretary's office	98.19
Corporation registration	1.00
Printing	340.75
Secretary, honorarium	100.00
Editor, honorarium	150.00
Research grant, W. M. Reid	75.00
Junior Academy	308.60
Total Expenditures	$ 1,231.20
Balance in the Commercial National Bank of Peoria	1,537.69
	$ 2,768.89

Statement of Resources, April 30, 1947

Balance in the Commercial Bank of Peoria	$ 1,537.69
Certificate of Interest for Meyer Block Leasehold	Value Unknown
Certificate of Interest for Forbes Building	Value Unknown
United States Savings Bonds, Series G	200.00
Total Resources	$ 1,737.69

The membership of the Academy consists of 60 life members, 92 new annual members, 18 sustaining members, 555 members paid up to and including the year 1947, 67 members one year in arrears, 39 members two years in arrears. The total membership is 831.

During the year 9 members have resigned, and 16 have removed, leaving no forwarding address.

(Signed) JOHN VOSS,
Treasurer.

(b) Report of the Committee on Auditing, May 1, 1947

To the Illinois State Academy of Science:

Your committee on auditing respectfully submits the following report:

We have examined the records of the Treasurer for the year May 1, 1946 to April 30, 1947, and find them correct. The present financial status of the Academy is as follows:

Cash on deposit with the Commercial National Bank of Peoria	$1,537.69
Series G., U. S. Savings bonds, two	200.00
Meyer Block Leasehold Certificate No. 15 (value unknown)	0.00
Forbes Building Certificate No. 13 (value unknown)	0.00
TOTAL ASSETS	$1,737.69

(Signed) L. P. Elliott, Chairman
W. W. Grimm

4. REPORT OF COMMITTEE ON SCIENCE TALENT SEARCH SCHOLARSHIPS

On March 8 a committee meeting was held in Urbana with Dr. Tehon and Dr. Shoemaker. It was decided to send a letter to the presidents of all colleges and universities in the state, outlining the plans for the State Talent Search and asking for scholarships from the various schools. The members of the committee were asked to help wherever possible in furthering the project. The letters to the college presidents were mailed on March 28. Because of the late start, the response was not as great as we had hoped for, because many schools had already made all of the scholarship commitments. However, scholarships were offered by the following schools: University of Chicago, Illinois College, Barat College of the Sacred Heart, Monmouth College, James Millikin University, Bradley University, MacMurray College, and Eureka College.

The committee on Science Talent Search selection awarded scholarships to fifteen students.

(Signed) Eliot C. Williams, Jr.,
Chairman

5. PUBLICATIONS COMMITTEE REPORT

The Publications Committee approved a plan whereby the authors' reprints from the Transactions would be ordered at the time the volume goes to press, the authors to purchase their reprints from the Academy at the following prices:

Copies	2pp.	4pp.	8pp.	12pp.	16pp.	24pp.	Covers
100	2.00	2.40	4.15	5.65	7.00	10.75	3.85
Additional 100's	1.00	1.40	2.20	2.95	3.30	5.20	1.40

6. REPORT OF THE COMMITTEE ON HIGH SCHOOL SCIENCE AND CLUBS

The committee recommended that the Junior Academy be extended to include grade school children, that the Senior Academy cooperate with the Science Clubs of America in a Science Talent Search program whereby promising high school students would be recommended for college scholarships, and that the teachers of student winners also be given certificates in recognition of their work. These were approved by the Senior Academy.

The committee adopted a simplified entry tag for use by student exhibitors.

A Science Field Day was held at Southern Illinois University, Carbondale, April 19, 1947. About 400 members representing 20 clubs attended the meeting, and displayed 148 exhibits.

About 400 students attended the annual May meeting at Peoria at which 175 exhibits were displayed. Awards were presented to winners after the banquet.

7. REPORT OF COMMITTEE ON RESOLUTIONS

Resolutions with Respect to the Final Disposition of Public Domain into Private Ownership

RESOLUTION No. 1

WHEREAS, it has come to the attention of the Illinois State Academy of Science that a small group of private interests are campaigning to have vast areas of public land transferred to private ownership: and

WHEREAS, a joint committee of cattlemen and woolgrowers has organized at Salt Lake City to achieve this end: and

WHEREAS, the following statement by J. Elmer Brock, vice-chairman of this committee, was published in The Denver Post on February 2, 1947:

> "The duties of the committee shall be to propose legislation for the final disposition of the public domain into private ownership."

And

WHEREAS, Mr. Brock has further stated publicly (quoted by *Trail and Timberline*, March 1947):

> "Eventually stockmen hope to return other (than Taylor lands) public grazing lands in the west to private owners, the men who now utilize those properties. The total grazing lands include some tracts now in the national forests and even some tracts which never should have been included in the national parks but have been placed there."

Therefore,

BE IT RESOLVED, that the Illinois State Academy of Science in annual meeting assembled at Peoria on Friday, May 2, 1947, go on record as upholding the belief that, considering the future need for more land for recreational use and considering the fact that the resources of grazing range and timber in these areas are now being nationally administered to good advantage, it would not be for the greatest public interest to permit the return of any land now included in National Parks or Forests to private ownership; and that the Academy declare its opposition to any bill which confers on private interests monopolistic control of public lands or which provides for the transfer of National Park and Forest areas into private ownership: and

BE IT FURTHER RESOLVED, that our Secretary be and is hereby directed to send copies of this resolution to the President of the United States, the U. S. Secretary of Agriculture, and the U. S. Secretary of the Interior, members of the U. S. Senate and the House of Representatives from Illinois, and the Secretary of the American Association for the Advancement of Science, and that a copy of this resolution be entered in the Transactions of the Academy, and

BE IT FURTHER RESOLVED, that the Conservation Committee of the Illinois State Academy of Science be and is hereby directed to give this matter their continued attention and to take whatever further action they may deem advisable in support of this resolution.

RESOLUTION No. 2.

WHEREAS, there has been some insistance that certain portions of the Olympic National Park in the State of Washington be returned to private ownership, for the benefit of commercial lumber interests, and

WHEREAS, certain bills have been introduced in Congress to effect these changes, and

WHEREAS, the National Park Service has recommended that some but not all of these tracts, totalling about 56,000 acres, be relinquished, generally for better administration and fire protection of the park, and

WHEREAS, there is also agitation to permit "selective" logging in the park, a procedure that would be contrary to the purpose of the park to preserve for the posterity of our country a relic of our original forest in its native condition,

BE IT RESOLVED, by the Illinois State Academy of Science in annual meeting assembled at Peoria on May 2, 1947, that in principle it is opposed to the release to private ownership of any land now in national parks and that with respect to the proposed release of certain tracts in the Olympic National Park, no more than that recommended by the National Park Service should be relinquished, and

BE IT FURTHER RESOLVED, that our Secretary be and is hereby directed to send copies of this resolution to the President of the United States, the U. S. Secretary of Commerce, the U. S. Secretary of the Interior, members of the U. S. Senate and the House of Representatives, and the Secretary of the American Association for the Advancement of Science, and that a copy of this resolution be entered in the Transactions of the Academy, and

BE IT FURTHER RESOLVED, that the Conservation Committee of the Illinois State Academy of Science be and is hereby directed to give this matter their continued attention and to take whatever further action they may deem advisable in support of this resolution.

RESOLUTION No. 3

WHEREAS, the sum of $50,000 requested by the National Park Service and included in the U. S. Department of Interior appropriation bill for preliminary surveys of archeological and paleontological sites within the Bureau of Reclamation and the Corps of Engineers projects have been reduced by half by the Committee on Appropriations, and

WHEREAS, such preliminary surveys are necessary to insure study and salvage of data at important sites before they are flooded, and

WHEREAS, the Committee has also removed the provision whereby any funds appropriated to one agency may be transferred to another for administration, an action that would hamper, if not prevent, such preliminary surveys,

BE IT RESOLVED, by the Illinois State Academy of Science in annual meeting assembled at Peoria on May 2, 1947, that it is opposed to any provisions in the U. S. Department of Interior appropriations bill restricting transfer of funds from one agency to another where such transfer is conducive to more effective administration, and

BE IT FURTHER RESOLVED, that our Secretary be and is hereby directed to communicate by telegraph this opinion to the proper authorities.

RESOLUTION No. 4

BE IT RESOLVED by the Illinois State Academy of Science in annual meeting assembled at Peoria on May 2, 1947, that the State of Illinois shall not relax its legal protection of predacious birds and that the goshawk, great horned owl, and birds predatory on fish be added to the list now afforded legal protection, and

BE IT FURTHER RESOLVED, that the proper representatives of our Academy be and are herewith directed to implement this resolution by whatever action may appear desirable and necessary.

RESOLUTION No. 5

BE IT RESOLVED, by the Illinois State Academy of Science in annual meeting assembled at Peoria on May 2 and 3, 1947, that it extend its appreciation to Bradley University, to the Peoria Academy of Science, to the Peoria Association of Commerce, to Mr. W. W. Grimm, and to all of those who have assisted him in arrangements for this meeting, and to all other organizations and individuals who have in any way contributed to the success of this meeting.